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THE UNIVERSITY OF KANSAS CENTER FOR RESEARCH, INC.

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## KANSAS ENVIRONMENTAL AND RESOURCE STUDY: A GREAT PLAINS MODEL

## SPECTRAL AND TEXTURAL PROCESSING OF ERTS IMAGERY

#### **PREFACE**

A procedure is developed to extract cross-band textural features from ERTS multi-spectral scanner imagery. Evolving from a single-image texture extraction procedure which uses spatial dependence matrices to measure relative co-occurrence of nearest neighbor grey tones, the cross-band texture procedure uses the distribution of neighboring grey tone N-tuple differences to measure the spatial interrelationships, or co-occurrences, of the grey tone N-tuples present in a texture pattern. In both procedures, texture is characterized in such a way as to be invariant under linear grey tone transformations. However, the cross-band procedure compliments the single-image procedure by extracting texture information and spectral information contained in ERTS multi-images. Classification experiments show that when used alone, without spectral processing, the cross-band texture procedure extracts more information than the single-image texture analysis. Results show an improvement in average correct classification from 86.2% to 88.8% for ERTS image no. 1021-16333 with the cross-band texture procedure. However, when used together with spectral features, the single-image texture plus spectral features perform better than the cross-band texture plus spectral features, with an average correct classification of 93.8% and 91.6%, respectively.

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# KANSAS ENVIRONMENTAL AND RESOURCE STUDY: A GREAT PLAINS MODEL

Use of Feature Extraction Techniques for the Texture and Context Information in ERTS Imagery:

Spectral and Textural Processing of ERTS Imagery

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#### I. INTRODUCTION

A procedure is developed to extract textural features for automatic analysis of ERTS multi-spectral scanner imagery. Previous work (Haralick, 1973; Haralick, 1972) indicates that useful textural features can be computed from the co-occurrence matrices for grey tones in specific spatial relationships on an image. The performance of the land-use classification algorithm using these textural features from only one band is encouraging; up to 75 per cent of the images were correctly classified (Haralick, 1973). Since textural features and spectral features of ERTS multi-images provide different kinds of information, a significant increase in identification accuracy will occur when both features are used together.

Adoption of the texture procedure for multi-images leads to excessive amounts of storage for the grey tone N-tuple co-occurrence matrices. Therefore, to solve the storage problem we measure grey tone N-tuple differences instead of grey tone N-tuples and assume an ellipsoidally symmetric functional form for the co-occurrence distribution of multi-image grey tone N-tuple differences.

It is expected that the estimated parameters of the ellipsoidally symmetric distribution will lead to textural features that can distinguish between texturally distinct categories on ERTS MSS images over Kansas. In order to obtain more texture information, the dimensionality of the grey tone N-tuples was increased from the original four MSS bands by the addition of cross-band product terms for higher order components. This procedure for cross-band texture analysis of multi-images provides a natural extension of the single-image texture analysis while retaining its advantages: invariance under translating and scaling transformations, low storage requirements, and direct proportionality between the number of operations required to process an image and the number of resolution cells present in an image.

#### 11. TEXTURE

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Texture and tone are two fundamental pattern elements used in the interpretation of image data. The concept of tone is concerned with the whiteness, greyness, or blackness of resolution cells of the image. The concept of texture is concerned with the spatial distribution of the grey tones. Tone is based upon the varying shades of grey of the resolution cells in the image, while texture is based upon the spatial distribution of grey tones. However, texture and tone are not independent concepts but are intrinsically related to one another. Although either property can dominate the other depending upon the image context, texture and tone are always present.

When one attempts to objectively use tone and texture pattern elements, the texture-tone concept must be explicitly defined. This can be visualized as follows. When a small area patch of an image has little variation of features of discrete grey tone, then that area is dominated by tonal properties. As the number of distinguishable features of discrete grey tone increases within the patch, then the texture properties will dominate. The size of the small area patch, the relative sizes of the discrete features and the number of distinguishable discrete features are all crucial in this distinction. When the size of the small area patch is reduced to one resolution cell, the only property present is tone. When there is no spatial pattern in the tonal features and the grey tone variation between features is wide, a fine texture results. And as the spatial pattern becomes more defined using more and more resolution cells, then a coarser texture results.

Texture can be termed as being fine, coarse, smooth, rippled, mottled irregular, or lineated. Texture is a property of nearly all surfaces, the grain of wood, the weave of fabric, the pattern of crops in a field, etc. Although texture is quite easy for humans to recognize and describe, it is quite subjective by its nature and is extremely difficult to precisely define and analyze by digital computers. Since the texture of images contains important information for discrimination purposes, textural features could be very useful.

#### III. REVIEW OF PAST WORK ON TEXTURE

To date there has been at least six different approaches to the problems of measuring and characterizing texture of images: autocorrelation functions, optical transforms, digital transforms, edgeness, structural elements, and spatial grey tone co-occurrence probabilities. The first three approaches all measure spatial frequency either directly or indirectly. Spatial frequency is related to texture because fine textures are rich in high frequencies while coarse textures are rich in low frequencies.

One alternative approach to viewing texture as spatial frequency distribution is to view texture as the amount of edgeness per unit area. Fine textures have a high number of edges per unit area whereas coarse textures have a small number of edges per unit area.

The structural element approach uses a matching procedure to detect the spatial regularity of shapes called structural elements in a binary image. When the structural elements themselves are single resolution cells, the information provided by this approach is the autocorrelation function of the binary image. By using larger and more complex shapes, a more generalized autocorrelation can be computed.

The grey tone spatial dependence approach characterizes texture by the spatial distribution of its grey tones. In coarse textures the distribution changes only slightly with distance, but for fine textures it changes rapidly with distance.

Because of our familiarity with the concepts of spatial frequency and edgeness, these approaches to texture characterizations are readily employed. However, an inherent problem exists with these approaches in regard to grey tone calibration of the image and they are not invariant under even a linear grey tone translation. And the price paid for invariance by compensating with quantization is a loss of grey tone precision in the quantized image.

The power of the structural element approach is that it emphasizes the shape aspects of the discrete tonal features. Weakness of this approach lies in that it can only do so for binary images.

The power of the spatial grey tone co-occurrence approach lies in characterizing the spatial inter-relationships of the grey tones in a texture pattern in such a way that is invariant under monotonic grey tone transformations. Weakness of the approach lies in failure to capture the shape aspects of the discrete tonal features.

(

#### IV. TEXTURAL FEATURES

1

The above description of texture is an idealization of what actually occurs, a gross simplification. Discrete tonal features are actually quite subjective in that they do not necessarily stand out as entities by themselves. Therefore, the texture analysis presented here is concerned with more general or macroscopic concepts rather than discrete tonal features. The procedure developed by Haralick (Haralick, 1972) for obtaining the textural features of an image is based on the assumption that the texture information on an image I is contained in the overall spatial co-occurrence relationship which the greytones in the image I have to one another. More specifically, we assume that this texture information is adequately specified by a set of spatial grey tone dependence matrices, which are computed for various angular relationships and distances between neighboring resolution cell pairs on the image. All of the textural features are then derived from these angular nearest neighbor spatial grey tone dependence matrices.

#### IV.1 Spatial Grey Tone Dependence Matrices

Let  $G = \{0, 1, ..., Ng\}$  be the set of possible grey tones that each resolution cell can take on after image normalization by equal probability quantizing to Ng levels. It can be shown that this quantization quarantees that images which are a monotonic transformation of one another, such as lighter or darker images due to variations in film, lighting, or development, will produce the same results. Let Nx be the number of resolution cells in the horizontal direction and Ny the number of resolution cells in the vertical direction in the image to be analyzed so that  $Lx = \{1, 2, ..., Nx\}$  and  $Ly = \{1, 2, ..., Ny\}$  are the horizontal and vertical spatial domains. Then  $Ly \times Lx$  will be the set of resolution cells of the image. And the image I can be represented as a function which assigns some grey tone in G to each resolution cell or pair of coordinates in  $Ly \times Lx$ ; I:Ly  $x \perp x \neq G$ .

Essential to our conceptual framework of texture are four closely related measures called angular nearest neighbor grey tone spatial dependence matrices. The concept of angular nearest neighbor for a resolution cell is the adjacent resolution cell for a given angle, as shown in Figure 1.

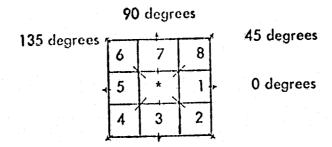


FIGURE 1. Eight nearest neighbor resolution cells of cell'\*.

Resolution cells 1 and 5 are the 0-degree nearest neighbors to resolution cell '\*', resolution cells 2 and and 6 are the 135-degree nearest neighbors, etc.

Note that this information is purely spatial, having nothing to do with grey tone values.

We assume that the texture information in our image I is contained in the overall or "average" spatial relationship which the grey tones in image I have to one another. Specifically, we shall assume that this information is adequately specified by the matrix of relative frequencies Pij with which two neighboring resolution cells separated by distance d occur on the image, one with grey tone i and the other with grey tone j. These matrices of spatial grey tone dependence frequencies are a function of the angular relationship between the neighboring resolution cells as well as a function of the distance between them. Figure 2 illustrates the set of all horizontal neighboring resolution cells separated by distance 1. This set along with the image grey tones would be used to calculate a distance i horizontal spatial grey tone coroccurrence matrix Formally, for angles quantized to 45° intervals the unnormalized frequencies are defined by:

are defined by: 
$$P(i,i,d,0^{\circ}) = \#\{((k,1),(m,n)) \in (L_{y} \times L_{x}) \times (L_{y} \times L_{x}) \mid k-m=0, |l-n| = d, |l(k,1)=i, |l(m,n)=i\}$$

$$P(i,i,d,45^{\circ}) = \#\{((k,1),(m,n)) \in (L_{y} \times L_{x}) \times (L_{y} \times L_{x}) \mid (k-m=d, |l-n| = d) \text{ or } (k-m=-d, |l-n| = d), |l(k,1)=i, |l(m,n)=i\}$$

$$P(i,i,d,90^{\circ}) = \#\{((k,1),(m,n)) \in (L_{y} \times L_{x}) \times (L_{y} \times L_{x}) | |k-m| = d, |l-n=0|, |l(k,1)=i|, |l(m,n)=i|\}$$

$$P(i,i,d,135^{\circ}) = \#\{((k,1),(m,n)) \in (L_{y} \times L_{x}) \times (L_{y} \times L_{x}) | |(k-m=d, |l-n=d) \text{ or } (k-m=-d, |l-n=-d), |l(k,1)=i|, |l(m,n)=i|\}$$

Note that these matrices are symmetric; P(i, j; d, a) = P(j, i; d, a). The distance metric P(i, j; d, a) = P(j, i; d, a). The distance metric P(i, j; d, a) = P(j, i; d, a). The distance metric P(i, j; d, a) = P(j, i; d, a).

(1,1)	(1,2)	(1,3)	(1,4)
(2,1)	(2,2)	(2,3)	(2,4)
(3,1)	(3,2)	(3,3)	(3,4)
(£ 1)	(4,2)	(4,3)	(4,4)

(

((

((

$$L_y = \{1, 2, 3, 4\}$$
  
 $L_x = \{1, 2, 3, 4\}$ 

$$R_{H} = \left\{ ((k,1),(m,n)) \in (L_{y} \times L_{x}) \times (L_{y} \times L_{x}) \middle| k-m=0, |1-n|=1 \right\}$$

$$= \left\{ ((1,1), (1,2)), ((1,2), (1,1)), ((1,2), (1,3)), ((1,3), (1,2)), ((1,3), (1,4)), ((1,4), (1,3)), ((2,1), (2,2)), ((2,2), (2,1)), ((2,2), (2,3)), ((2,3), (2,2)), ((2,3), (2,4)), ((2,4), (2,3)), ((3,1), (3,2)), ((3,2), (3,1)), ((3,2), (3,3)), ((3,3), (3,2)), ((3,3), (3,4)), ((3,4), (3,3)), ((4,1), (4,2)), ((4,2), (4,1)), ((4,2), (4,3)), ((4,3), (4,3)), ((4,3), (4,4)), ((4,4), (4,3)) \right\}$$

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FIGURE 2. Illustrates the set of all Distance I Horizontal Neighboring Resolution Cells on a  $4\times4$  Image.

6

For an example of the four distance 1 grey tone spatial dependence matrices, consider Figure 3. Figure 3-a represents a 4 x 4 image with four grey tones, ranging from 0 to 3. Figure 3-b shows the general form for any grey tone spatial dependence matrix. For example, the element in the (2,1)-st position of the distance 1 horizontal PH matrix is the total number of times two grey tones of value 2 and 1 occurred horizontally adjacent to each other. To determine this number, we count the number of pairs of resolution cells in RH such that the first resolution cell of the pair has grey tone 2 and the second resolution cell of the pair has grey tone 1. Figure 3-c through 3-f shows all four distance 1 grey tone spatial dependence matrices.

From the grey tone dependence matrices a set of 17 textural features is derived. The equations defining these 17 features are given in Appendix 1. To illustrate the significance of these features, three are defined as follows:

$$f_1 = \sum_{i=1}^{N_g} \sum_{j=1}^{N_g} \left( \frac{P(i,j)}{\#_R} \right)^2,$$

$$f_{12} = \sum_{n=0}^{N_g-1} n^2 \left\{ \sum_{|i-j|=n} \left( \frac{P(i,j)}{\#R} \right) \right\}$$

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$$f_3 = \frac{\sum_{j=1}^{g} \sum_{j=1}^{g} \frac{ij P(i,j)}{\#_R} - \mu_x \mu_y}{\sigma_x \sigma_y}$$

(

#R = number of resolution cells pairs, and  $\mu_{x}$  and  $\sigma_{x}$  are the mean and standard deviation of the marginal distribution Px defined by

$$P_{x}(i) = \sum_{j=1}^{N_g} \frac{P(i,j)}{\#_R}$$

and  $\mu_y$  and  $\sigma_y$  are the mean and standard deviation of the marginal distribution  $P_y$ defined by:

$$P_{y}(j) = \sum_{i=1}^{N_g} \frac{P(i,j)}{\#_R}$$

0	0	ו	1
0	0	1	1
0	2	2	2
2	2	3	3

Figure 3-a.

Figure 3-b. This shows the general form of any grey tone spatial dependence matrix for an image with integer grey tone values 0 to 3. #(i,j) stands for number of times grey tones i and j have been neighbors.

$$P_{H} = \begin{pmatrix} 4 & 2 & 1 & 0 \\ 2 & 4 & 0 & 0 \\ 1 & 0 & 6 & 1 \\ 0 & 0 & 1 & 2 \end{pmatrix}$$

(

Figure 3-c.

90°
$$P_{V} = \begin{pmatrix} 6 & 0 & 2 & 0 \\ 0 & 4 & 2 & 0 \\ 2 & 2 & 2 & 2 \\ 0 & 0 & 2 & 0 \end{pmatrix}$$
Figure 3-d.

$$\begin{array}{c} 135^{\circ} \\ P_{LD} = \begin{pmatrix} 2 & 1 & 3 & 0 \\ 1 & 2 & 1 & 0 \\ 3 & 1 & 0 & 2 \\ 0 & 0 & 2 & 0 \end{pmatrix} \end{array}$$

Figure 3-e.

45°
$$P_{RD} = \begin{pmatrix} 4 & 1 & 0 & 0 \\ 1 & 2 & 2 & 0 \\ 0 & 2 & 4 & 1 \\ 0 & 0 & 1 & 0 \end{pmatrix}$$
Figure 3-f.

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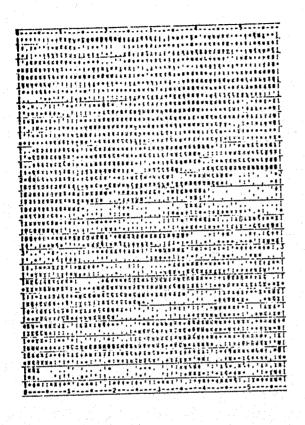
To explain the significance of these features, let us consider the kind of values they take on two different land use category images. Figure 4 shows the digital printout of two sub-images of size  $64 \times 64$  resolution cells (approximately 8.5 square mile area) from MSS band 5 of 1002-18134, see Figure 10. The image shown in 4 (a) belongs to the grass land category and the image in Figure 4(b) is mostly water. Values of the features  $f_1$ ,  $f_{12}$ , and  $f_3$  are also shown for these images in Figure 4.

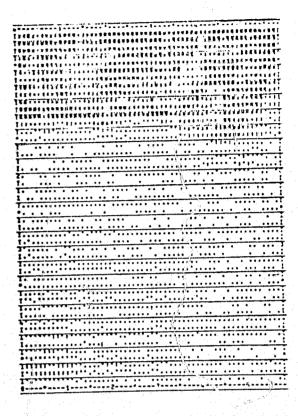
The angular second moment feature (ASM), f<sub>1</sub>, is a measure of homogeneity of the image. In a homogeneous image, such as shown in 4(b), there are very few dominant grey tone transitions. Hence, the P matrix for this image will have fewer entries of large magnitude. For an image like the one shown in Figure 4(a), the P matrix will have a large number of small entries and hence the ASM feature which is the sum of squares of the entries in the P matrix will be smaller. A comparison of the ASM values given below the images in Figure 4 shows the usefulness of the ASM feature as a measure of the homogeneity of the image.

The contrast feature, f<sub>12</sub>, is obtained as a difference moment of the P matrix and is a measure of the contrast or the amount of boundaries present in an image. Since there is a large amount of boundaries present in the image 4(a) compared to the image shown in 4(b), the contrast feature for the grassland image has consistently higher values compared to the water body image.

The correlation feature,  $f_3$ , is a measure of linear grey tone dependencies in the image. For both the images shown in Figure 4, the correlation feature is somewhat higher in the horizontal  $(0^{\circ})$  direction, along the line of scan. The water body image consists mostly of a constant grey tone value for the water plus some additive noise. Since the noise samples are mostly uncorrelated, the correlation features for the water body image have lower correlation values compared to the grassland image. Also the grassland image has a considerable amount of linear structure along  $45^{\circ}$  lines across the image and hence the value of the correlation feature is higher along this direction compared to the values for  $90^{\circ}$  and  $135^{\circ}$  directions.

The various features presented here are all functions of distance and angle. The angular dependencies present a special problem. Suppose image A has features a, b, c, d for angles 0°, 45°, 90°, and 135° and image B is identical to A except that B is rotated 90° with respect to A. Then B will have features c, d, a, b, for angles 0°, 45°, 90°, and 135° respectively. Since the texture





#### a. Grassland

b. Water Body

Angle	ASM	Contrast	Correlation	ASM	Contrast	Correlation
0°	.0128	3.048	.8075	.1016	2.153	.7254
45°	.0080	4.011	.6366	.0771	3.057	.4768
20°	.0077	4.014	.5987	.0762	3.113	.4646
135 <sup>0</sup>	.0064	4.709	.4610	.0741	3.129	.4650
Avg.	.0087	3.945	.6259	.0822	2.863	.5327

Figure 4. Textural Features for Two Different Land Use Category Images.

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context of A is the same as the texture context of B, any decision rule using the angular features a, b, c, d must produce the same results for c, d, a, b, or for that matter b, c, d, a (45° rotation) and d, a, b, c, (135° rotation). To guarantee this, we do not use the angularly dependent features directly. Instead, we merge the four arrays by summing corresponding elements. The merged array is then used for computing the 17 texture features defined in Appendix I.

#### IV.2 Textural Features for Multi-Images

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Results of previous work in texture using the spatial grey tone dependence matrices as the basis from which all textural features are extracted has been very encouraging (Haralick, 1973). The good performance of these texture features can be seen by the results of the classification experiments. The computational aspects of the procedure are also notable. The number of operations required to process an image using the spatial grey tone dependence matrices is directly proportional to the number of resolution cells, N, present in an image. In comparison, the number of operations needed to use Fourier or Hadamard transforms to extract texture information are of the order of N log N. And, to compute the entries in the spatial grey tone dependence matrices, one needs to keep only two lines of image data in core at a time, keeping storage requirements to a minimum.

Even with these advantages, however, the extraction of texture information from multiimages, as in the case of ERTS MSS data, forces a new approach to the measurement of grey tone N-tuple co-occurrences. The use of the spatial dependence matrices requires that they be stored in the computer. For multi-images containing grey tone N-tuples, we have too many possible grey tone N-tuples which can neighbor each other and as a result, the dependence matrices will be very large. For example, for four MSS bands in which each grey tone can range through 64 levels, each matrix would have 64 x64 elements. Even using the symmetry of the matrices to reduce the number of entries does not help since there would be on the order of 10 to entries.

The spatial dependence matrices, however, provide a way of escape. In using these matrices, it was observed that they are heavily weighted along the diagonal with decreasing entries farther from the diagonal. Figure 5 gives an

example of one of these matrices. Note that the number of entries decreases as we move away from the diagonal. This suggests that neighboring resolution cells are similar. Choosing any resolution cell in an image at random, we are very likely to find nearly identical neighbors to the cell in all directions and less likely to find dissimilar neighbors. Clearly, a measure which indicates how similar the neighboring N-tuples are and how fast the similarity drops off with distance must contain textural information about the object imaged.

It is therefore reasonable to measure the difference between neighboring grey tone N-tuples and observe this distribution instead of computing the number of times each N-tuple neighbors every other N-tuple. In both cases we measure the co-occurrence of nearest neighbor grey tone N-tuples.

Since the textural features are based on the spatial dependence of grey tone N-tuples, our first step must be to define a binary relation between neighboring resolution cells on which the co-occurrence of grey tone N-tuples can be counted. As above, let  $Lx = \{1, 2, ..., Nx\}$  and  $Ly = \{1, 2, ..., Ny\}$  be the set of column and row indexes, respectively, so that  $Ly \times Lx$  is the set of resolution cells in the image. Let  $G = \{0, 1, ..., Ng\}$  be the set of possible grey tones that each component of every grey tone N-tuple can be assigned. Then, the image I can be defined by I:Ly  $\times Lx \rightarrow GxGx...xG$ .

Let R be the set of all pairs of resolution cells in a specified spatial relation. Then R is a binary relation on the set Ly  $\times$  Lx;  $R\subseteq$ (Ly  $\times$  Lx)  $\times$  (Ly  $\times$  Lx). For example, the set of all distance 1 horizontally neighboring pairs of neighboring resolution cells would be defined by:

$$R = \{((k, 1), (m, n)) \in (Ly \times Lx) \times (Ly \times Lx) \mid k-m=0, |I-n|=1\}.$$

The co-occurrence frequency of grey tone N-tuples  $(i_1, i_2, ..., i_N)$  and  $(j_1, j_2, ..., j_N)$  in spatial relation defined by R is  $P\left((i_1, ..., i_N), (j_1, ..., j_N)\right) = \frac{\#\left\{\left((k, 1), (m, n)\right) \in R \mid I(k, 1) = (i_1, ..., i_N), I(m, n) = (j_1, ..., j_N)\right\}}{\#_{P}}$ 

where # denotes the number of elements in the set.

Note that this R is symmetric. Assume that ((k, 1), (m, n)) is in R. Then k-m=0, and |1-n|=1 from the definitions of R. But |1-n|=1 when |n-1|=1.

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24 26
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                                                    FIGURE 5. Example of Nearest Neighbor Grey Tone
                                                                Dependence Matrices, Taken from Processing
                                                                ERTS Data.
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And if |n-1|=1 and k-m=0, then ((m, n), (k, 1)) is in R. Thus, R is symmetric. In fact, by the symmetry of any distance function, R, in general, must be symmetric. And since R is symmetric, P is also symmetric.

## IV.3 Textural Feature Extraction Procedure

Let R be a symmetric binary relation pairing nearby neighboring resolution cells. We define the frequency of grey tone N-tuple differences co-occurring in the spatial configuration defined by R as

 $P(x_{1}, x_{2}, ..., x_{N}) = \frac{\# \left\{ ((i, j), (m, n)) \in \mathbb{R} \mid I(i, j) - I(m, n) = (x_{N}) \right\}.}{\#_{\mathbb{R}}}$ 

Note that P is an even function since  $P(x_{1}, x_{2}, ..., x_{N}) = \# \left\{ ((i, j), (m, n)) \in \mathbb{R} \mid I(i, j) - I(m, n) = \begin{pmatrix} x_{1} \\ x_{N} \end{pmatrix} \right\} / \# \mathbb{R}$   $= \# \left\{ ((i, j), (m, n)) \in \mathbb{R}^{-1} \mid I(i, j) - I(m, n) = \begin{pmatrix} x_{1} \\ x_{N} \end{pmatrix} \right\} / \# \mathbb{R}$   $= \# \left\{ ((m, n), (i, j)) \in \mathbb{R} \mid I(i, j) - I(m, n) = \begin{pmatrix} x_{1} \\ x_{N} \end{pmatrix} \right\} / \# \mathbb{R}$   $= \# \left\{ ((m, n), (i, j)) \in \mathbb{R} \mid I(m, n) - I(i, j) = \begin{pmatrix} x_{1} \\ x_{N} \end{pmatrix} \right\} / \# \mathbb{R}$   $= \mathbb{R} \left\{ ((m, n), (i, j)) \in \mathbb{R} \mid I(m, n) - I(i, j) = \begin{pmatrix} x_{1} \\ x_{N} \end{pmatrix} \right\} / \# \mathbb{R}$   $= \mathbb{R} \left\{ ((m, n), (i, j)) \in \mathbb{R} \mid I(m, n) - I(i, j) = \begin{pmatrix} x_{1} \\ x_{N} \end{pmatrix} \right\} / \# \mathbb{R}$ 

Referring to the monotonic behavior of nearly every column in the matrices of Figure 5, and assuming that this behavior occurs on every band of the ERTS multi-images, it is reasonable to assume that the even frequency distribution  $P(x_1, \dots, x_N)$  of the nearby grey tone N-tuple differences can be adequately approximated using an ellipsoidally symmetric distribution; thus we may write

$$P(x_1, x_2, ..., x_N) = f(x^r Ax)$$
 for some monotonically decreasing function f.

This implies that only the function f and the matrix A need to be determined. We take f to be one of the two forms  $e^{-1/2 \ln^2}$ ,  $(1+\mu^2)^{-m}$ . Figure 6 is a scattergram of the differences for the first two bands of distance 1 horizontally neighboring resolution cells of a 64x64 sample image. Figures 6 and 7 clearly show the ellipsoidally symmetric functional form of the distribution of neighboring differences. In Appendix II N-dimensional spherical coordinate systems and ellipsoidally symmetric distributions are discussed and it is shown that the matrix A is proportional to the inverse covariance matrix of the N-tuple differences. Thus, we estimate A by a matrix proportional to the inverse of the estimate for the covariance matrix.

Therefore, if the image is blocked into subimages of small area so that each subimage is essentially of one category, we can expect the distribution of grey tone N-tuple differences over each subimage to be a function only of the assumed form of the function f and the covariance matrix of the difference vectors for grey tone N-tuples in a specified spatial relationship within the subimage. This leads us to consider textural features for multi-images based upon the elements of this spatial-spectral covariance matrix.

Consider each covariance matrix as a vector. Consider the distribution of the set of covariance matrices from the blocked image. Since the entries of the covariance matrix are the parameters of the distribution, we would like to have these entries invariant with respect to scale changes on the grey tone N-tuple differences. In order to do this, we scale the grey tone N-tuple differences so that all components have variance 1. The covariance matrix of these normalized differences is equivalent to the correlation matrix. Appendix III shows that this normalization procedure makes the covariance matrix invariant with respect to translating and scaling transformations on the grey tone N-tuples. The normalized covariance matrix can be considered as an extracted texture feature vector in an N(N-1)/2 dimensional hyperspace.

Initial classification experiments indicated a need for more textural information and in order to provide this the dimensionality, N, of each resolution cell was increased from the four provided by the four MSS bands to eight by appending higher order terms and cross-band product terms for each cell. The resultant increase in correct classification accuracy can be seen in section VII.

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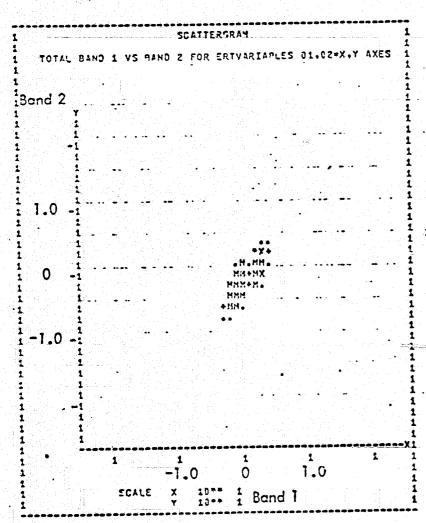


FIGURE 6. Scattergram showing ellipsoidally symmetric distribution of differences for Bands 4 and 5 over a sample 64 x 64 ERTS image.

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FIGURE 7. Histogram of the distribution of differences on Band 5 for distance 1 horizontally neighboring resolution cells.

#### V. GROUND TRUTH ASSIGNMENT PROCEDURE

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For all classification experiments, the only method available to determine ground truth was based upon the 9 inch by 9 inch ERTS image transparency. Initially, the land-use category names were determined with the aid of two photo interpreters and, when available, contour maps published by the U.S. Geological Survey.

After the categories to be used were decided upon, each ERTS image was processed. The image was blocked into 64 x 64 subimages for texture analysis on MSS band 5 and 32 by 32 subimages for cross-band texture analysis of MSS bands 4 thru 7. The ERTS Retrieval Program was then used to printout a picture of the same area that was processed. This was subdivided into 64 x 64 subimages. In this way, the location of each subimage was known and could be fairly accurately determined on a 7 inch by 7 inch print. Then, on the basis of its location, the subimage is assigned a ground truth category. Figure 8 shows a picture printout by the ERTS Retrieval Program for a portion of image 1021-16333 (see Figure 12) over Kansas City. The picture has been blocked into 64 x 64 subimages and by refering to the original image in Figure 12, each subimage was assigned a ground truth category.

Figures 8 and 12 also illustrate the major problem with ground truth assignment. This is the determination of ground truth when a subimage covers more than one ground truth category. The irregular boundary around the urban area of Kansas City makes ground truth assignment difficult. The deciding factor was the amount of area within the subimage from each category. The subimage was assigned to the category which had the largest area within its boundary. For this reason the accuracy with which the location of every subimage is determined becomes very important, and the picture printouts from the retrieval programs aided in this.

Since the starting and ending image row and column coordinates were known, the Retrieval Program could use the same coordinates for the picture printout. This printout could then be accurately divided into 64 by 64 subimages. The actual location of these subimages could then be determined fairly well, although it is sometimes difficult to locate objects in the printout that are on the original image. To aid in this, a few of the well defined objects were used to construct a 64 by 64 grid on the 7 inch by 7 inch

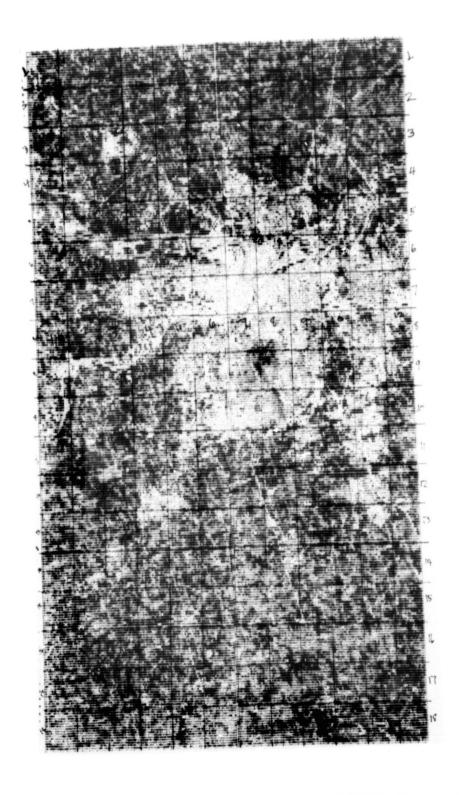


Figure 8. Printout of a Portion of Image 1021–16333 Over Kansas City by the ERTS Retrieval Program for Use in Ground Truth Assignment.

print. When there was a question in the ground truth, the printout could be referred to for the more accurate subimage location. The size of the subimage also relates directly to the accuracy with which its location on the print can be determined. It was found that 32 lines by 32 points per line was about as small as a subimage can be for good accuracy in ground truth assignment.

#### VI. IDENTIFICATION PROCEDURE

In the classification experiments two different classification algorithms were used, a Bayes classifier and a piecewise linear classifier. The Bayes classifier assumes a multivariate normal distribution and randomly choses pattern vectors for the training set where the piecewise linear classifier does not.

The problem of developing procedures for categorizing environmental units consists of the following.

With reference to Figure 9, the Universe  $\overline{U}$  consists of environmental units (for example rocks)  $U_1, U_2, \ldots, U_T$  which belongs to one of R possible categories  $C_1, C_2, \ldots, C_R$  (different land use categories). Of the large number of environmental units present in the universe, we observe a smaller subset of units  $U_1, U_2, \ldots, U_N$ . Our observations consist of a set of measured values of n features  $f_1, f_2, \ldots, f_n$  for each unit U sampled. Based on the information contained in the feature vectors  $F_1, F_2, \ldots, F_N$ , the categories of the environmental units which produce these measurements being known, we want to develop an algorithm to identify the categories of new units based on the measurements they produce.

The vectors  $F_i$  and  $X_i$  are usually referred to as feature vector and pattern vector respectively.

Figure 9. Identification Scheme.

 $\overline{X} = \left\{ X_1, X_2, \dots, X_T \right\}; \quad X = \left[ x_1 x_2 \dots x_m \right]^T$ 

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The decision rule which assigns categories based on the values of features may be implemented in the feature space  $\overline{F}$  by partitioning  $\overline{F}$  into various regions and assigning categories to new units based on the regions to which their feature vectors belong. Efficient partitioning of the feature space may require complicated nonlinear decision boundaries (discriminant functions). Instead of deriving a decision rule in the feature space  $\overline{F}$ , we may transform the feature vectors into a new space  $\overline{X}$  and implement a decision rule in the new space  $\overline{X}$ . By using appropriate nonlinear transformations, we may be able to implement nonlinear decision boundaries in  $\overline{F}$  as linear decision boundaries in  $\overline{X}$ . Several procedures are available for deriving linear decision boundaries for partitioning  $\overline{X}$  into various regions, based on the information contained in a set of sample patterns  $X_1, X_2, \dots, X_N$  whose categories are known.

Identification Algorithms: In a widely used algorithm (Fukunaga 1972, Fu and Mendel 1970, Miesel 1972), the pattern space X is separated into a number of regions using a set of hyperplanes (decision boundaries) whose locations are determined by the sample patterns. Each region is dominated by sample patterns of a particular category. When a new pattern is presented for identification, it is assigned a category depending on the region in which it belongs. If the new pattern X is located in a region dominated by sample patterns of category c; then X is classified as coming from category c:

To illustrate the procedure for obtaining the hyperplanes, consider the problem of separating the sample patterns  $X_1, X_2, \ldots, X_n$ , belonging to category  $c_i$  and  $X_n, X_n, \dots, X_n$ , belonging to category  $c_i$ . We can write the linear discriminant function (hyperplane) which separates the patterns belonging to categories  $c_i$  and  $c_i$  as

$$h_{ij}(X) = V_{ij}^{T}X + v_{ij}^{o} \ge 0 \text{ for } X \in c_{i},$$

$$h_{ij}(X) = V_{ij}^{T}X + v_{ij}^{o} < 0 \text{ for } X \in c_{j},$$

The vector  $V_{ij}$  and the scalar  $v_{ij}^{o}$  are to be determined from the information contained on the sample patterns.

If we introduce a new form to express the pattern vectors as

$$Z = \begin{bmatrix} +1 & x_1 & x_2 & \dots & x_n \end{bmatrix}^T \text{ for } X \in c_1$$

$$Z = \begin{bmatrix} -1 & -x_1 & -x_2 & \dots & -x_n \end{bmatrix}^T \text{ for } X \in c_1$$

then the discriminant function can be written as

$$h_{ij}(Z) = W_{ij}^{T}Z > 0$$
 (1)

where W.; is referred to as a weight vector and

$$h_{ij}(Z) = W_{ij}^T Z = 0$$

is the equation of a hyperplane in the transformed feature space.

The weight vector  $W_{ij}$  is chosen so as to satisfy equation 1 for as many training patterns as possible. Usually we do not know the precise form of  $h_{ij}$ . But, given our knowledge of the categories of the training patterns, we can postulate reasonable values  $g_{ij}$   $(Z_k)$  for  $h_{ij}$   $(Z_k)$  and choose  $W_{ij}$  to minimize the mean square error given by

 $\epsilon^2 = \frac{1}{n_i + n_i} \sum_{k=1}^{n_i + n_j} (W_{ij}^T Z_k - g_{ij} (Z_k))^2$ .

Usually  $g_{ij}$  ( $Z_k$ ) is taken to be +1 for  $k = 1, 2, ..., n_i + n_j$ . We can rewrite  $\epsilon^2$  as,  $\epsilon^2 = \frac{1}{(n_i + n_j)} [W_{ij}^T Y - G_{ij}^T] [Y^T W_{ij} - 1] \qquad (2)$ 

where

$$Y = [Z_1 Z_2 ... Z_{n_i + n_j}], \text{ and}$$

$$G_{ij} = [g_{ij}(Z_1) g_{ij}(Z_2) ... g_{ij}(Z_{n_i + n_i})].$$

The weight vector which minimizes  $\epsilon^2$  given in equation 2 is given by

$$W_{ij} = (YY^{T})^{-1} Y G_{ij}$$

which is the well-known normal equation set from linear least square theory.

For the multicategory problem involving  $N_R$  categories, a total of  $N_R$   $(N_R^{-1})/2$  hyperplanes must be determined using the procedure described above. After the hyperplanes are determined, the classification of new patterns is done as follows. For each category  $c_i$ , the number of hyperplanes,  $V_i$ , which give a positive response when the new pattern X is presented are determined using

$$V_{i} = \sum_{j=1}^{N_{R}} \frac{|W_{ij}^{T}Z| + W_{ij}^{T}Z}{2|W_{ij}^{T}Z|}; i = 1,2,...N_{R}$$

$$j \neq i \qquad 2|W_{ij}^{T}Z|$$

where

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$$Z = \begin{bmatrix} 1 \\ X \end{bmatrix}.$$

X is assigned to category ci if

$$V_j = \max_{i} \{V_i\}$$

If there is a tie between categories  $c_m$  and  $c_n$ , then X is assigned to  $c_m$  if  $W_{mn}^T Z \ge 0$  or to  $c_n$  if  $W_{mn}^T Z < 0$ . Several modifications of the linear discriminant function method and a multitude of other classification procedures may be found in the references cited.

## VII. RESULTS OF CLASSIFICATION EXPERIMENTS

Tables 1 thru 24 show the results of the classification experiments. Unless otherwise stated, the contingency tables are determined using the piecewise linear classification programs (RCLASS) given in Appendix IV. In each contingency table the number of errors (#ERR) and percent error (%ERR) is shown for both errors of commission and errors of ommission. The final entry in the percent error column is the average of the percent error for each category. The average correct classification is simply the number of correct classifications divided by the number of incorrect classifications. The final column in each contingency table (%SD) is an estimate for the standard deviation of the probability for correct classification. This was taken from Afarani (Afarani, 1972) where he gives an estimate for the variance of the probability of correct classification when the sample size is fixed as:

$$\hat{\sigma}^2 = \underbrace{\left(\sum_{i=j}^{n_{ii}}\right)\left(\sum_{\substack{i=j\\i\neq j}}^{n_{ij}}n_{ij}\right)}_{n^3} = \underbrace{\left(\begin{array}{c} no.\\ correct \end{array}\right)\left(\begin{array}{c} no.\\ errors \end{array}\right)}_{(total no.)^3}$$

where n is the fixed sample size and n; is the number of classifications of units assigned to category j whose true category is i. Used directly, this gives an estimate over all categories for the entire contingency table. This is the last entry in the percent standard deviation (%SD) column. The remaining entries were determined by fixing i and estimating the standard deviation for each category i. This estimate says that as the number of samples tested increases and the number of correct classifications increase, the variance of the probability of correct classification decreases, as one would expect.

In order to obtain an initial estimate of performance of the multi-image texture features an experiment was performed on ERTS satellite imagery over Monterey Bay, California, image number 1002-18134 (see Figure 10) taken on July 25, 1972. Using a small set of 64 sampled 32 x 32 subimages and training on 34 of these, 80 per cent of the remaining 30 test samples were correctly classified according to four land-use categories: coastal forest, annual grassland, urban area, and water, as shown in Table 1. This is encouraging since previous accuracy using spatial dependence matrices on band 5 with 64 by 64 subimages over the same general area was only 70.5 per cent as shown in Table 2 (Haralick, 1973).

The ability to obtain good ground truth and several distinct categories in the California data was not the case for an ERTS image over Finney County, Kansas, which was used in later experiments. Approximately a 40 mile by 60 mile section near Garden City, Kansas, on image number 1330-16515(see Figure 11), taken on June 18, 1973, was processed with initially four categories: grassland, large fields, small fields, and water. Both texture procedures, using the multi-image texture features with 32 by 32 subimages and the single-image texture analysis on MSS band 5 with 64 by 64 subimages, were used on the image. Tables 3 and 4 show the results of classification for distance 1 resolution cells while Tables 5 and 6 show distance 8 results. In both cases the single image classification is higher. However, when both distances 1 and 8 are used together, classification accuracy for both procedures is nearly identical, as shown in Tables 7 and 8, about 70 per cent. Tables 9 and 10 show results using the Bayes Classifier.

This implies that more information is contained in the single-band texture features than the multi-image texture features. In order to add more texture information, a measure of entropy (Kullbach, 1959), given by

$$E = -\frac{1}{2} \log |P|$$

where P is the correlation matrix, was added to the cross-band texture feature set.

Also, higher order components were appended to each grey tone N-tuple by squaring the grey tones and getting cross-band product terms. Only a few of these were added, increasing the grey toneN-tuple dimensionality from 4 to 8, which results in an increase in the number of feature vector components (elements in the correlation matrix) from 6 to 28 plus the entropy measure. The eight components in each grey tone N-tuple are: MSS Band 5, Band 6, Band 7, (Band 5)<sup>2</sup>, (Band 6)<sup>2</sup>, (Band 7)<sup>2</sup>, (Band 5) x (Band 6),

(Band 5)  $\times$  (Band 7). Figure 13 gives an illustration of a correlation matrix with the feature vector component designation to be used in indicating the components selected for input to the classification programs.

Table 11 shows the contingency table for the cross-band texture features using 9 of the 29 components (1,2,5,6,9,12, 20, 24, and 27 of figure 13) for a portion of the Garden City, Kansas, data. The increase in identification accuracy between the large and small fields results in an increase in overall correct classification, up to 87.1%.

The final classification experiment to test the cross-band texture analysis was made on ERTS image 1021-16333 (see Figure 12) taken on August 13, 1973, over Kansas City. Four land-use categories were chosen: cropland (directly north and south of Kansas City), urban area (Kansas City, Topeka), grassland (southwestern corner of the image), and water (Perry reservoir plus several small lakes). These areas were processed three separate ways:

- 1) spectrally, 32 by 32 subimages
- 2) texturally, 64 by 64 subimages on band 5
- and 3) cross-band texturally, 32 by 32 subimages.

Because of problems with ground truth and a small data set for water, that category was later dropped. The spectral processing involved obtaining the average grey tone over the subimage for each spectral band, giving 4 components for each feature vector. The textural processing was over a larger subimage than either the spectral or the crossband textural processing. This was chosen because the 64 by 64 subimages have performed better in the past than the 32 by 32 subimages for the single-image texture analysis. The smaller subimage size was chosen for the cross-band texture processing so that the subimage would more likely be from only one category. The cross-band texture method uses spectral information which the single-image texture procedure does not have available. The smaller subimage size was also chosen for the spectral processing in order to provide an estimate of the amount of spectral information contained in the four MSS bands that is available to the cross-band texture analysis.

Single-image texture analysis was done for distance 1 nearest neighbors at all angles and all of the 17 texture features defined in Appendix I were computed for each subimage. The cross-band texture processing was also done for distance 1 using horizontally adjacent nearest neighbor grey tone N-tuples.

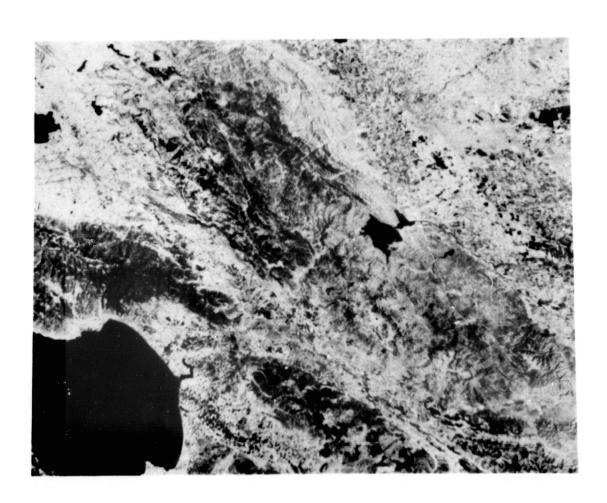


Figure 10. Part of ERTS Image No. 1002–18134 (MSS Band 5) Over Monterey Bay, California, Taken on July 25, 1972.

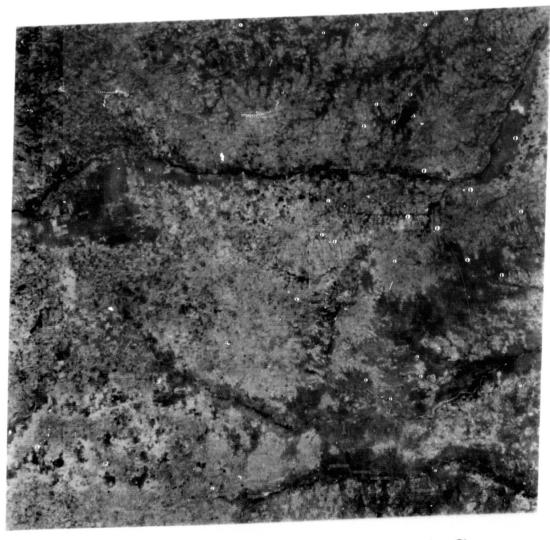


Figure 11. ERTS Image No. 1330–16515 (MSS Band 5) Over Garden City, Kansas, Taken on June 18, 1973.

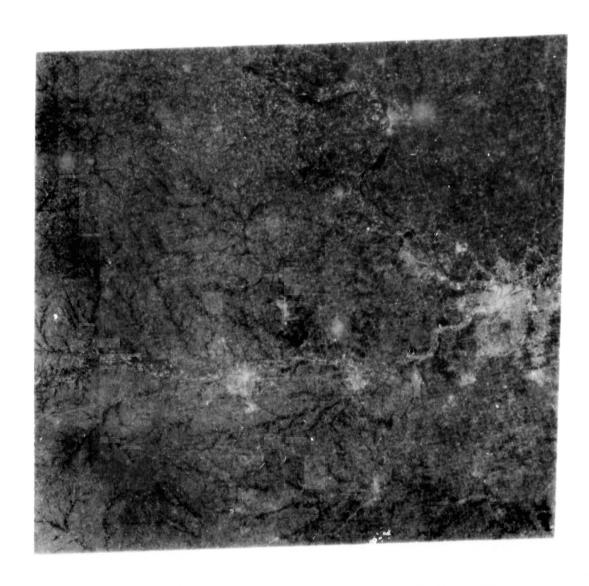


Figure 12. ERTS Image No. 1021–16333 Over (MSS Band 5) Kansas City, Taken on August 13, 1972.

	BAND 5	BAND 6	BAND 7	(BAND 5) <sup>2</sup>	(BAND 6) <sup>2</sup>	(BAND 7) <sup>2</sup>	(BAND 5) x(BAND 6)	(Band 5) ×(Band 7)
BAND 5	1							
BAND 6	F(2)	1						
BAND 7	F(3)	F(9)	1					
(BAND 5) <sup>2</sup>	F(4)	F(10)	F(15)	1				
(BAND 6) <sup>2</sup>	F(5)	F(11)	F(16)	F(20)	1			<u> </u>
$(Band 7)^2$	F(6)	F(12)	F(17)	F(21)	F(24)	1		
(BAND 5) (BAND 6)	F(7)	F(13)	F(18)	F(22)	F(25)	F(27)	1	
(BAND 5)(BAND 7)	F(8)	F(14)	F(19)	F(23)	F(26)	F(28)	F(29)	1

Entropy = F(1)

FIGURE 13. DESIGNATION OF THE ENTROPY MEASURE AND ELEMENTS OF THE CORRELATION MATRIX AS FEATURE VECTOR COMPONENTS FOR CROSS-BAND TEXTURE ANALYSIS OF MULTI-IMAGES.

Table 12 shows the contingency table for all 17 single-image texture features over image 1021-16333 with an average correct classification of 86.2%. Table 13 shows the resulting contingency table over the same image for the 29 cross-band texture features with an increased correct classification of 88.8%. The spectral processing on the four MSS bands for the same image gave four spectral features—the mean grey tone over the subimage for each spectral band. The resulting contingency table using these four spectral features is shown in Table 14. The relatively good performance, 73.9% correct, shows a significant amount of land-use information is contained in the four spectral bands, accounting for the better performance of the cross—band texture analysis over the single-image texture analysis.

It is interesting to see the classification accuracy of the single-image texture greatly improve to 93.8% with the addition of the four spectral features to the original 17 texture features, as shown in Table 15. As expected, the addition of the four spectral features to the first 26 of the 29 cross-band texture features does not improve the classification accuracy as well as with the single-image texture. Table 16 shows the resulting contingency table with an average correct classification of 91.6%. Note the higher estimate for the standard deviation of the probability for correct classification with the textural plus spectral features.

These tables show that the single-image texture procedure does well in extracting texture information, but for this data set, the cross-band texture procedure by itself performs slightly better by extracting more information texturally and spectrally.

The remaining tables show the effect upon classification accuracy of using fewer features. In each case it can be seen that the fewer the number of features used, the lower the average correct classification. Also, it can be seen that the Bayes classifier performs slightly better than the piecewise linear classifier.

Tables 20 thru 24 show that as the number of components is increased, the spectral plus cross-band texture reaches a limiting accuracy of approximately 92%.

Ground truth assignment errors could easily account for the remaining 8% error.

## VII.1 Summary of Classification Results

It is apparent from these classification experiments that both texture extraction procedures complement each other in that they extract different kinds of texture information. When used without spectral features, the cross-band texture procedure performed better. However, when the spectral features were added, the single-image texture plus spectral features performed better than the cross-band texture plus spectral features. This indicates that the cross-band texture procedure does well in

extracting more information texturally and spectrally than the single-image texture procedure. However, when the spectral information is made available to the single-image texture procedure, it performs better than the cross-band texture plus spectral features.

Programs used in these experiments can be found in Appendix IV. The single-image texture programs are under the Texture Analysis Programs with mainline MAINLN. And the cross-band texture programs are in the Cross-Band Texture Analysis Programs with mainline SPECTR. RCLASS is the mainline program for the piecewise linear classifier. Some of the cross-band texture feature components can be seen in Figure 14. Figure 14a shows the ground truth assignment for the image 1021-16333 (Figure 12) for the area near Kansas City. At the bottom of the image, grassland was inserted to give an idea of how well the features separate the three categories: cropland, urban area, and grassland.

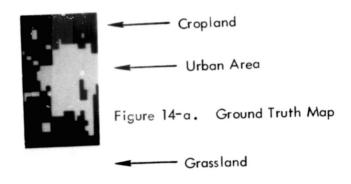
### VIII. CONCLUSION

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The procedure developed here for the extraction of texture information from ERTS multi-images gives encouraging results. The classification experiments show that the cross-band texture procedure can be used successfully in automatic landuse classification of multi-images over Kansas.

The cross-band texture procedure is a natural extension of the previous single-image texture extraction procedure based upon angular nearest neighbor grey tone spatial dependence matrices. It retains the power of the previous approach to texture by characterizing the spatial inter-relationships, or co-occurrences, of the grey tone N-tuples present in a texture pattern in such a way as to be invariant under linear grey tone transformations. And both procedures are simple to employ, economical, and require a minimum of core-storage (see Figure 15).

Both procedures complement each other by extracting different kinds of textural information with the cross-band texture procedure using the cross-band spectral information contained in ERTS multi-images. Results indicate that the cross-band texture procedure does well by extracting more information texturally and spectrally than the single-image texture procedure when used alone. However, when the spectral information is made available to the single-image texture procedure, it performs better than the cross-band texture plus spectral features in classifying texturally distinct land-use categories from ERTS multi-images over Kansas.



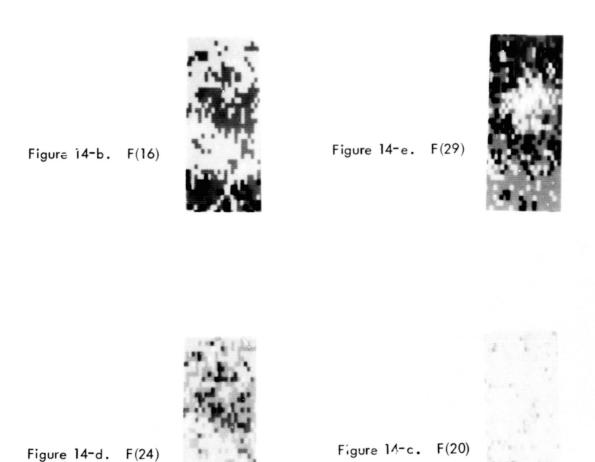


Figure 14. Examples of Cross-Band Texture Feature Vector Components; Resolution Cell Size is 32 x 32

	Core Required	Total Processing Time	Total Job Cost	Cost Per Resolution Cell
SINGLE-IMAGE TEXTURE (64×64)	43ĸ	0.788HR	\$223.	\$0.000252
CROSS-BAND TEXTURE (32×32)	25к	0.884HR	\$216.	\$0,000244

Figure 15. Comparison of the Performance of the Single-Image Texture Analysis Programs on MSS Band 5 with the Cross-Band Texture Analysis Programs on MSS Bands 4 thru 7 in Processing the Same Area.

Near Kansas City.on ERTS Image No. 1021-16333 using a Honeywell 635 Computer.

			ASSIGNED	CATEGO	RY		ERROPS COMMIS		
	*	COASTAL FOREST	ANNUAL GRASSLAND	URBAN AREA	WATER	TOTAL	#ERR	ZERR	%SD
	COASTAL FOREST	5	0	5	0	10	5	50.	15.8
CATEGORY	ANNUAL GRASSLAND	0	7	0	0	7	0	0.	0.
	URBAN AREA	0	1	7	0	8	1	14.3	11.7
TRUE	WATER	0	0	0	5	5	0	0.	0.
	TOTAL	5	8	12	5	30		21.4	7.3
SOF	#ERRORS	0	1	7	0				
ERRORS	%error	0.	12.5	58.3	0.	17.7			

TABLE 1. CONTINGENCY TABLE FOR IMAGE NO. 1002-18134 USING MULTI-IMAGE TEXTURAL FEATURES, 6 COMPONENTS. AVERAGE CORRECT CLASSIFICATION ON TEST SET=80.0%\*

EEATURES	NO. OF SAMPLES IN TRAINING SET	NO. OF SAMPLES IN TEST SET	OVERALL ACCURACY OF TEST SET
MULTI-IMAGE TEXTURAL	34	30	80.0%
SINGLE-IMAGE TEXTURAL	260	172	70.5%

TABLE 2. RESULTS OF LAND-USE CLASSIFICATION EXPERIMENTS FROM ERTS IMAGE NO. 1002-18134 OVER MONTEREY BAY, CALIFORNIA.

<sup>\*</sup>Unless stated otherwise, all contingency tables are determined using the piecewise linear classification programs (rclass).

			ASSIGNED	CATEGOR	RΥ		ERROR COMMI	S OF	
		GRASSLAND	LARGE FIELDS	SMALL FIELDS	WATER	TOTAL	#ERR	%ERR	%SD
	GRASSLAND	47	11	5	0	63	16	25.4	5.5
ORY L	LARGE FIELDS	3	142	32	1	178	36	20.2	3.0
CATE	SMALL FIELDS	17	46	52	0	115	63	31.3	4.6
TRUE	WATER	0	1	6	1	8	2	25.0	11.7
	TOTAL	67	200	95	2	364		25.5	2.5
S 07	#ERRORS	20	58	43	1				
ERRORS OMMISS	%ERROR	29.9	29.0	45.3	50.	38.6			

TABLE 3. CONTINGENCY TABLE FOR IMAGE NO. 1330-16515 USING MULTI-IMAGE TEXTURAL FEATURES, DISTANCE 1, 6 COMPONENTS. AVERAGE CORRECT CLASSIFICATION = 66.5%

EEATURES	NO. OF SAMPLES IN TRAINING SET	NO. OF SAMPLES IN TEST SET	OVERALL ACCURACY OF TEST SET
MULTI-IMAGE TEXTURAL	548	364	66.5%
SINGLE-IMAGE TEXTURAL	140	88	76%

TABLE 4. RESULTS OF LAND-USE CLASSIFICATION EXPERIMENTS FOR ERTS IMAGE NO. 1330-16515 AT DISTANCE 1.

			ASSIGNED	CATEGO	RY		ERROF COMM!	RS OF	
		GRASSLA:ID	LARGE F1ELDS	SMALL FIELDS	WATER	TOTAL.	#ERR	%ERR	%SD
$\neg$	GRASSLAND	32	9	22	0	63	31	49.2	6.3
CATEGORY	LARGE FIELDS	7	147	24	0	178	31	17.4	2.8
CATE	SMALL FIELDS	18	44	53	0	115	62	53.9	4.6
TRUE	WATER	0	4	4	0	8	4	50.0	0.
	TOTAL	57	204	103	0	364		42.6	2.5
101	#ERRORS	25	57	50	0				
RORS	%ERROR	43.9	27.9	48.5	0.	30.1			

TABLE 5. CONTINGENCY TABLE FOR IMAGE NO. 1330-16515 USING MULTI-IMAGE TEXTURAL FEATURES, DISTANCE 8, 6 COMPONENTS. AVERAGE CORRECT CLASSIFICATION = 63.7%

EEATURES	NO. OF SAMPLES IN TRAINING SET	NO. OF SAMPLES IN TEST SET	OVERALL ACCURACY OF TEST SET	
MULTI-IMAGE TEXTURAL	548	364	63.7%	
SINGLE-IMAGE TEXTURAL	140	88	76%	

TABLE 6. RESULTS OF LAND-USE CLASSIFICATION EXPERIMENTS FOR ERTS IMAGE NO. 1330-16515 AT DISTANCE 8.

			ASSIGNED	CATEGOR	Υ		ERROR COMMI		
		GRASSLAND	LARGE F1ELDS	SMALL FIELDS	WATER	TOTAL.	#ERR	ZERR	%SD
	GRASSLAND	52	7	4	0	63	11	17.5	4.8
CATEGORY	LARGE FIELDS	2	145	31	0	178	33	18.5	2.9
CATE	SMALL FIELDS	12	42	61	0	115	54	47.0	4.7
TRUE	WATER	0	1	6	1	8	7	87.5	11.7
	TOTAL	66	195	102	1	364	L,	42.6	2.4
101	#ERRORS	14	50	41	0				
ERRORS (	%error	21.2	25.6	40.2	0.	21.8			

TABLE 7. CONTINGENCY TABLE FOR IMAGE NO. 1330-16515 USING MULTI-IMAGE TEXTURAL FEATURES, DISTANCES 1 AND 8, 12 COMPONENTS. AVERAGE CORRECT CLASSIFICATION =71%

EEATURES	NO. OF SAMPLES IN TRAINING SET	NO. OF SAMPLES IN TEST SET	OVERALL ACCURACY OF TEST SET
MULTI-IMAGE TEXTURAL	548	364	71%
SINGLE-IMAGE TEXTURAL	140	88	73%

TABLE 8. RESULTS OF LAND-USE CLASSIFICATION EXPERIMENTS FOR ERTS IMAGE NO. 1330-16515 USING BOTH DISTANCES 1 AND 8.

			ASSIGNED	CATEGO	RY		ERRORS OF			
		GRASSLAND	LARGE FIELDS	SMALL FIELDS	WATER	τοτλι.	#err	Zerr	%SD	
	GEASSLAND	49	4	6	1	60	11	18.3	5.0	
CATEGORY	LARGE FIELDS	6	150	27	1	184	34	18.5	2.9	
	SHALL FIELDS	10	34	67	2	113	46	40.7	4.6	
TRE	WATER	0	4	0	4	8	4	31.9	17.7	
	TOTAL	65	192	100	8	365		31.9	2.3	
001	#ERRORS	16	42	33	4					
ERRORS DAMISSI	%error	24.6	21.9	33.0	50.0	32.4				

TABLE 9. CONTINGENCY TABLE FOR IMAGE NO. 1330-16515 USING MULTI-IMAGE TEXTURAL FEATURES, DISTANCE 1.6 COMPONENTS. AVERAGE CORRECT CLASSIFICATION = 74.0% USING BAYES.

			ASSIGNED	CATEGO	RY		ERRORS COMMIS		
		GRASSLAND	LARGE FIELDS	SMALL FIELDS	WATER	TOTAL	#ERR	ZERR	%SD
	GRASSLAND	31	10	19	0	60	29	48.3	6.5
CATEGORY	LARGE FIELDS	5	140	38	1	184	44	23.9	3.1
CATE	SMALL FIELDS	12	46	51	4	113	62	54.9	4.7
TRUE	WATER	1	4	2	1	8	7	87.5	11.7
	TOTAL.	49	200	110	6	365		53.7	2.6
RS OF	#ERRORS	18	50	59	5				
ERRORS OFMISS	%error	36.7	25.0	53.6	83.3	49.7			

TABLE 10. CONTINGENCY TABLE FOR IMAGE NO.1330-16515 USING MULTI-IMAGE TEXTURAL FEATURES, DISTANCE 8,6 COMPONENTS. AVERAGE CORRECT CLASSIFICATION =61.1% USING BAYES.

		AS	SIGNED CA	TEGORY		ERRO! COMM!	RS OF ISSION	
		GRASSLAND	LARGE FIELDS	SMALL FIELDS	TOTAL	#ERR	%ERR	%SD
	GRASSLAND	35	3	0	38	3	7.9	4.4
CATEGORY	LARGE FIELDS	2	12	2	16	4	25.0	10.8
	SMALL FIELDS	0	2	14	16	2	12.5	8.3
TRUE	TOTAL	37	17	16	70		15.1	4.0
OF I ON	#ERRORS	2	5	2				
EPRORS OMMISSI	%ERROR	5.4	29.4	12.5	15.8			

Table 11. Contingency table for image No. 1330-16515 using 9 of the 29 cross-band textural features, distance 1. #TRAIN=103, #TEST=70, AVERAGE CORRECT CLASSIFICATION = 87.1% using the bayes classifier. The 9 feature components used were: 1,2,5,6,9,12,20,24,27.

		А	SSIGNED CAT	TEGORY		ERROR COMMI		
		CROPLAND	URBAN	GRASSLAND	TOTAL	#ERR	%ERR	%SD
≿:	CROPLAND	61	2	1	64	3	4.7	2.6
: CATEGORY	URBAN	6	18	0	24	6	25.0	8.8
TRUE CA	GRASSLAND	6	1	21	28	7	25.0	8.2
TR	TOTAL	73	21	22	116		18.2	3.2
OF	#ERRORS	12	3	1				
ERRORS (	%error	16.4	14.2	4.5	11.7			

TABLE 12. CONTINGENCY TABLE FOR ERTS IMAGE 1021-16333 USING ALL 17 SINGLE-BAND TEXTURE FEATURES AT DISTANCE 1. #TRAIN=178, #TEST=116, AVERAGE CORRECT CLASSIFICATION = 86.2%

		A	SSIGNED CA	TEGORY		ERRO COMM	RS OF ISSION	
		CROPLAND	URBAN	GRASSLAND	TOTAL	#ERR	%ERR	%SD
	CROPLAND	150	15	3	168	18	10.7	2.4
CATEGORY	URBAN	11	81	0	52	11	12.0	3.4
E CAT	GRASSLAND	11	2	103	116	13	11.2	2.9
TRUE	TOTAL	172	98	106	376		11.3	1.6
OF 10N	#ERRORS	22	17	3		h		
ERRORS OMMISSI	%ERROR	12.8	17.3	2.8	11.0			

TABLE 13. CONTINGENCY TABLE FOR ERTS IMAGE 1021-16333 USING ALL 29 CROSS-BAND TEXTURE FEATURES AT DISTANCE 1.

#TRAIN = 569, #TEST = 376, AVERAGE CORRECT CLASSIFICATION = 88.8%

		A	SSIGNED CA	TEGORY		ERROR COMMI	S OF SSION	
		CROPLAND	URBAN	GRASSLAND	TOTAL	#ERR	%ERR	%SD
RY	CROPLAND	138	9	22	169	37	21.9	3.0
CATEGORY	URBAN	8	53	30	91	38	41.8	5.2
TRUE CA	GRASSLAND	20	8	84	112	28	25.0	4.1
TR	TOTAL	166	70	136	372		29.6	2.3
0 P	#ERRORS	28	17	52				
ERRORS	%ERROR	16.9	24.3	38.2	26.5			

TABLE 14. CONTINGENCY TABLE FOR ERTS IMAGE 1021-16333 USING SPECTRAL FEATURES ONLY. #TRAIN=564, #TEST=372

AVERAGE CORRECT CLASSIFICATION = 73.9%

	- 1	AS	SSIGNED CA	TEGORY		ERRO COMM	RS OF	
		CROPLAND	URBAN	GRASSLAND	TOTAL	#ERR	%ERR	%SD
	CROPLAND	62	2	0	64	2	3.1	2.2
CATEGORY	URBAN	4	19	1	24	5	20.8	8.3
	GRASSLAND	0	0	24	24	0	0.0	0.0
TRUE	TOTAL	66	21	25	112		8.0	2.3
OF 10N	#ERRORS	4	2	1				
ERRORS (	%error	6.1	9.5	4.0	6.5			

TABLE 15. CONTINGENCY TABLE FOR ERTS IMAGE 1021-16333 USING ALL 17 SINGLE-IMAGE TEXTURE PLUS THE 4 SPECTRAL FEATURES, 21 COMPONENTS, #TRAIN=175, #TEST=112 AVERAGE CORRECT CLASSIFICATION = 93.8%

		A	ASSIGNED CA	TEGORY		ERROR COMMI	S OF SSION	
		CROPLAND	URBAN	GRASSLAND	TOTAL	#ERR	%ERR	%SD
≿:	CROPLAND	155	12	1	168	13	7.7	2.1
CATEGORY	URBAN	12	80	0	92	12	13.0	3.5
TRUE CA	GRASSLAND	4	2	103	109	6	5.5	2.2
TR	TOTAL	171	94	104	369	<u> </u>	8.7	1.4
OF	#ERRORS	16	12	1				
ERRORS OMMISS	%ERROR	9.4	12.8	1.0	7.7			

TABLE 16. CONTINGENCY TABLE FOR ERTS IMAGE 1021-16333 USING FIRST 26 CROSS-BAND TEXTURE PLUS THE 4 SPECTRAL FEATURES, 30 COMPONENTS. #TRAIN=567, #TEST=369

AVERAGE CORRECT CLASSIFICATION = 91.6%

		A	SSIGNED CA	TEGORY		ERRO COMM	RS OF	
		CROPLAND	URBAN	GRASSLAND	TOTAL	#ERR	%ERR	%SD
	CROPLAND	60	1	3	64	4	6.2	3.0
CATEGORY	URBAN	8	16	0	24	8	33.3	9.6
	GRASSLAND	5	1	22	28	6	21.4	7.8
TRUE	TOTAL	73	18	25	116		20.3	3.4
0F 10N	#ERRORS	13	2	3				
ERRORS OMMISSI	%error	17.8	11.1	12.0	13.6			

TABLE 17. CONTINGENCY TABLE FOR ERTS IMAGE 1021-16333 USING FIRST 8 OF THE 17 SINGLE-IMAGE TEXTURE FEATURES.

#TRAIN=178,#TES1=116, AVERAGE CORRECT CLASSIFICATION = 84.5%

		1	SSIGNED CA	ATEGORY		ERROR COMMI	S OF SSION	
		CROPLAND	URBAN	GRASSLAND	TOTAL	#ERR	%ERR	%SD
<b>\</b>	CROPLAND	138	22	8	168	30	17.9	3.0
CATEGORY	URBAN	21	68	3	92	24	26.1	4.6
	GRASSLAND	20	5	91	116	25	21.6	3.8
TR	TOTAL	179	95	102	376		21.9	2.1
S OF TRUE	#ERRORS	41	27	11				
ERRORS	ZERROR	22.9	28.4	10.8	20.7			

TABLE 18. CONTINGENCY TABLE FOR ERTS IMAGE 1021-16333 USING FIRST 9 OF THE 29 CROSSBAND TEXTURE FEATURES.

#TRAIN=569, #TEST=376, AVERAGE CORRECT CLASSIFICATION = 79.0%

		A	SSIGNED CA	TEGORY		ERRO COMM	RS OF ISSION	
		CROPLAND	URBAN	GRASSLAND	TOTAL	#ERR	%ERR	%SD
	CROPLAND	142	25	4	171	29	17.0	2.9
CATEGORY	URBAN	20	66	5	91	25	27.5	4.7
	GRASSLAND	12	5	95	112	17	15.2	3.4
TRUE	TOTAL	174	96	104	374		19.9	2.0
0F 10N	#ERRORS	32	30	9				
ERRORS (	%ERROR	18,4	31.3	8.7	19.5			

TABLE 19. CONTINGENCY TABLE FOR ERTS IMAGE 1021-16333 USING FIRST 9 OF THE 29 CROSS-BAND TEXTURE FEATURES.

#TRAIN=562, #TEST=374, AVERAGE CORRECT CLASSIFICATION = 81.0% USING THE BAYES CLASSIFIER.

		-	ASSIGNED CA	TEGORY		ERROR COMM I	S OF SSION	
		CROPLAND	URBAN	GRASSLAND	TOTAL	#ERR	%ERR	%SD
λ.	CROPLAND	158	6	2	166	8	4.8	1.7
CATEGORY	URBAN	13	58	. 18	89	31	34.8	5.1
TRUE CA	GRASSLAND	9	10	93	112	19	17.0	3.5
TR	TOTAL	180	74	113	367		18.9	1.9
OF	#ERRORS	22	16	20				
ERRORS (	%ERROR	12.2	21.6	17.7	17.2			

Table 20. Contingency table for erts image 1021-16333 using first 6 of the 29 cross-band texture plus the 4 spectral features, #train=569, #test=367, average correct classification = 84.2%

		I	ASSIGNED C	ATEGORY		ERRORS OF COMMISSION		
		CROPLAND	URBAN	GRASSLAND	TOTAL	#ERR	%ERR	%SD
	CROPLAND	61	2	1	64	3	4.7	2.6
CATEGORY	URBAN	3	19	2	24	5	20.8	8.3
E CAT	GRASSLAND	0	0	24	24	0	0.0	0.0
TRUE	TOTAL	64	21	27	112		8.5	2.4
OF 10N	#ERRORS	3	2	3				
ERRORS (	%ERROR	4.7	9.5	11.1	8.4			

TABLE 21. CONTINGENCY TABLE FOR ERTS IMAGE. 1021-16333 USING FIRST 9 OF THE 17single-image texture plus the 4 spectral FEATURES, #TRAIN=175, #TEST=112, AVERAGE CORRECT CLASSIFICATION = 92.9%

		ı	SSIGNED CA	ATEGORY		ERROR COMMI	S OF SSION	
		CROPLAND	URBAN	GRASSLAND	TOTAL	#ERR	%ERR	%SD
	CROPLAND	161	7	0	168	7	4.2	1.5
CATEGORY	URBAN	15	77	0	92	15	16.3	3.9
TRUE CA	GRASSLAND	9	6	97	112	15	13.4	3.2
TR	TOTAL	185	90	97	372		11.3	1.6
OF	#ERRORS	24	13	0				
ERRORS OMMISS	%ERROR	13.0	14.4	0.0	9.1			

TABLE 22. CONTINGENCY TABLE FOR ERTS IMAGE 1021-16333 USING FIRST 11 OF THE 29 CROSS-BAND TEXTURE PLUS THE 4 SPECTRAL FEATURES, #TRAIN=564, #TEST=372, AVERAGE CORRECT CLASSIFICATION = 90.1%

•		ASSIGNED CATEGORY					ERRORS OF COMMISSION		
		CROPLAND	URBAN	GRASSLAND	TOTAL	#ERR	%ERR	%SD	
TRUE CATEGORY	CROPLAND	159	8	0	167	8	4.8	1.7	
	URBAN	15	76	1	92	. 16	17.4	4.0	
	GRASSLAND	7	5	100	112	12	10.7	2.9	
	TOTAL	181	89	101	371		11.0	1.5	
ERRORS OF OMMISSION	#ERRORS	22	13	1					
	%ERROR	12.2	14.6	1.0	9.3				

TABLE 23. CONTINGENCY TABLE FOR ERTS IMAGE. 1021-16333 USING FIRST 16 OF THE 29 CROSS-BAND TEXTURE PLUS THE 4 SPECTRAL FEATURES, #TRAIN=565, #TEST=371, AVERAGE CORRECT CLASSIFICATION = 90.3%

	•		1					,
		ASSIGNED CATEGORY				ERRORS OF COUMISSION		
		CROPLAND	URBAN	GRASSLAND	TOTAL	#ERR	ZERR	%SD
TRUE CATEGORY	CROPLAND	156	9	1	166	10	6.0	1.8
	URBAN	13	79	. 0	92	13	14.1	3.6
	GRASSLAND	G	1	103	110	7	6.4	2.3
	TOTAL	175	89	104	368		8.8	1.4
ERRORS OF OMMISSION	#ERRORS	19	10	1		i ľ		
	%error	10.9	11.2	1.0	7.7			

TABLE 24. CONTINGENCY TABLE FOR ERTS IMAGE 1021-16333 USING FIRST 21 OF THE 29 CROSS-BAND TEXTURE PLUS THE 4 SPECTRAL FEATURES, #TRAIN=568, #TEST=368, AVERAGE CORRECT CLASSIFICATION = 91.9%

#### APPENDIX I

# TEXTURAL FEATURES OBTAINED FROM THE GREY TONE DEPENDENCE MATRIX

In this appendix, we define 17 textural features which are computed for each of the four angular grey tone dependence matrices.

The following notation will be used in defining the 17 textural features.

 $P(i,j) - (i,j)^{th}$  entry in a particular grey tone dependence matrix.

 $\frac{P_{\mathbf{x}}(i)}{\#R} \begin{cases} -i^{th} \text{ entry in the marginal distributions of P(i,j) obtained by} \\ \text{summing rows and columns of P(i,j) respectively.} \end{cases}$ 

 $\frac{P_{y}(i)}{\#_{R}}$ 

#R - number of resolution cell pairs which were considered in computing the entries in P(i,j).

N<sub>2</sub> - number of distinct grey tone values in the image.

 $\mu$  - mean of P(i,j)/#R.

Px+y (i)-i<sup>th</sup> entry in the distribution of the sum of grey tones of neighboring resolution cells.

 $\frac{P_{x-y}}{\#_R}$  (i) ith entry in the distribution of the absolute differences in the grey tones of neighboring resolution cells.

### TEXTURAL FEATURES

1. Angular Second Moment:

$$f_1 = \sum_{i=1}^{N_g} \sum_{j=1}^{N_g} \left\{ \frac{P(i,j)}{\#_R} \right\}^2$$

2. Entropy:

$$f_2 = \sum_{i=1}^{N_g} \sum_{j=1}^{N_g} -\left(\frac{P(i,j)}{\#_R}\right) \log \left(\frac{P(i,j)}{\#_R}\right)$$

3. Correlation:

$$f_3 = \frac{\sum_{j=1}^{N_g} \sum_{j=1}^{N_g} \left\{ \frac{P(i,j)}{\#_R} \right\} - \mu_x \mu_y}{\sigma_x, \sigma_y}$$

where  $\mu_{x}$  and  $\sigma_{x}$  are the mean and standard deviation of  $P_{x}$ , and  $\mu_{y}$  and  $\sigma_{y}$  are the mean and standard deviation of  $P_{y}$ .

4. Sum of Squares on x:

$$f_4 = \sum_{i=1}^{N_g} \sum_{j=1}^{N_g} (i-\mu)^2 \left\{ \frac{P(i,j)}{\#_R} \right\}$$

5. Product Moment:

4

$$f_5 = \sum_{i=1}^{N_g} \sum_{j=1}^{N_g} (i-\mu)(j-\mu) \left\{ \frac{P(i,j)}{\#_R} \right\}$$

6. Inverse Moment:

$$f_6 = \sum_{i=1}^{N_g} \sum_{j=1}^{N_g} \frac{1}{1 + (i-j)^2} \left\{ \frac{P(i,j)}{\#_R} \right\}$$

7. Difference Moment:

$$f_7 = \sum_{i=1}^{N_g} \sum_{j=1}^{N_g} (i-j)^2 \left\{ \frac{P(i,j)}{\#_R} \right\}$$

8. Sum Average:

$$f_8 = \sum_{i=1}^{2N_g} i \left\{ \frac{P_{x+y}(i)}{\frac{\#}{R}} \right\}$$

9. Mean: 
$$N_g = \frac{1}{N_g} \sum_{i=1}^{N_g} \frac{P(i, j)}{\# R}$$

10. Sum Variance:

$$f_{10} = \text{variance of } P_x + \sqrt{\#R}$$

11. Sum Entropy:

$$f_{11} = \sum_{i=1}^{2N_g} - \left\{ \frac{P_{x+y}(i)}{\#_R} \right\} \log \left\{ \frac{P_{x+y}(i)}{\#_R} \right\}$$

12. Contrast:

$$f_{12} = \sum_{n=0}^{N_{g-1}} n^2 \begin{cases} \sum_{i=1}^{N_g} \sum_{j=1}^{N_g} \binom{P(i,j)}{\# R} \\ |i-i| = n \end{cases}$$

13. Difference Variance:

$$f_{13} = \text{variance of } \frac{P_{x-y}}{\#_R}$$

14. Difference Entropy:

$$f_{14} = \sum_{i=0}^{N_{g-1}} - \left\{ \frac{P_{x-y}(i)}{\#_R} \right\} \log \left\{ \frac{P_{x-y}(i)}{\#_R} \right\}$$

15, 16, 17. Additional Measures of Correlation:

$$f_{15} = \frac{HXY - HXY1}{max HX, HY}$$

$$f_{16} = \sqrt{1 - \exp[-2.0(HXY2 - HXY)]}$$

$$f_{17} = \sqrt{\text{second largest eigenvalue of } QQ^{T}}$$

where HX and HY are the entropies of the marginals of the transition matrix before quantization, HXY is the entropy of the transition matrix, and HXY2 is the entropy of the product distribution of the marginals before quantization;

$$Q(i,j) = P(i,j)/\sqrt{P_x(i)P_y(j)}.$$

<sup>\*</sup>f17 is the maximal correlation coefficient.

### APPENDIX II

# N-DIMENSIONAL SPHERICAL COORDINATE SYSTEMS AND ELLIPSOIDALLY SYMMETRIC DISTRIBUTIONS

We illustrate the N-dimensional spherical coordinate system in the calculation of the volume of the N-dimensional hypersphere. Next we show how suitable functions can be used to define ellipsoidally symmetric density functions and we determine the normalizing constant for any function. Finally, we show that for any ellipsoidally symmetric density  $f(\sqrt{x^T Ax})$ , the matrix A is proportional to the inverse covariance matrix of x and we determine the constant of proportionality.

## II.1 Volume of an N-dimensional Hypersphere

Let V be the volume of a N-dimensional hypersphere of radius r<sub>o</sub>. By definition

$$\mathbf{v} = \int \int \dots \int dx_1 dx_2 \dots dx_N$$

$$\sqrt{\sum_{j=1}^{N} x_i^2} \leq \mathbf{r_o}$$

To evaluate this N-fold integral, we transform to spherical coordinates.

$$x_1 = r \cos \theta_1 \cos \theta_2 \cdots \cos \theta_{N-3} \cos \theta_{N-2} \cos \theta_{N-1}$$

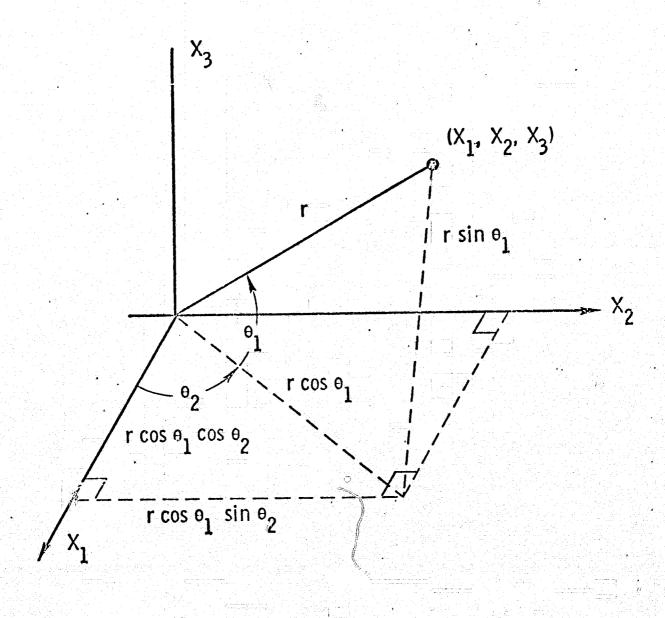
$$x_2 = r \cos \theta_1 \cos \theta_2 \cdots \cos \theta_{N-3} \cos \theta_{N-2} \sin \theta_{N-1}$$

$$x_3 = r \cos \theta_1 \cos \theta_2 \cdots \cos \theta_{N-3} \sin \theta_{N-2}$$

$$x_j = r \cos \theta_1 \cos \theta_2 \cdot \cos \theta_{N-j} \sin \theta_{N-j}$$

$$x_N = r \sin \theta_1$$

Figure 16 illustrates the geometry of the spherical coordinate system we use for a 3-dimensional system.



$$x_1 = r \cos \theta_1 \cos \theta_2$$

$$x_2 = r \cos \theta_1 \sin \theta_2$$

$$x_3 = r \sin \theta_1$$

Transformation between rectangular coordinate system and spherical coordinate system.

Figure 16 Three-Dimensional Spherical Coordinate System

The Jacobian J of this transformation is defined by the determinant J.

$$\mathbf{J} = \begin{bmatrix} \frac{\partial \mathbf{x}_{1}}{\partial \mathbf{r}} & \frac{\partial \mathbf{x}_{2}}{\partial \mathbf{r}} & \cdots & \frac{\partial \mathbf{x}_{N}}{\partial \mathbf{r}} \\ \frac{\partial \mathbf{x}_{1}}{\partial \theta_{1}} & \frac{\partial \mathbf{x}_{2}}{\partial \theta_{1}} & \cdots & \frac{\partial \mathbf{x}_{N}}{\partial \theta_{1}} \end{bmatrix}$$

$$\vdots$$

$$\frac{\partial \mathbf{x}_{1}}{\partial \theta_{N+1}} & \frac{\partial \mathbf{x}_{2}}{\partial \theta_{N+1}} & \cdots & \frac{\partial \mathbf{x}_{N}}{\partial \theta_{N+1}}$$

$$\cos \theta_1 \cos \theta_2 \cdots \cos \theta_{N-1} \qquad \cos \theta_1 \cos \theta_2 \cdots \cos \theta_{N-2} \sin \theta_{N-1} \qquad \sin \theta_1$$

$$-r \sin \theta_1 \cos \theta_2 \cdots \cos \theta_{N-1} \qquad -r \sin \theta_1 \cos \theta_2 \cdots \cos \theta_{N-2} \sin \theta_{N-1} \cdots r \cos \theta_1$$

$$-r \cos \theta_1 \sin \theta_1 \cdots \cos \theta_{N-1} \qquad -r \cos \theta_1 \sin \theta_2 \cdots \cos \theta_{N-2} \sin \theta_{N-1} \cdots \qquad 0$$

$$\vdots \qquad \vdots \qquad \vdots \qquad \vdots$$

$$-r \cos \theta_1 \cos \theta_2 \cdots \sin \theta_{N-1} \qquad r \cos \theta_1 \cos \theta_2 \cdots \cos \theta_{N-2} \cos \theta_{N-2} \cos \theta_{N-1} \cdots \qquad 0$$

To find the value of the Jacobian, factor r out of the last (N-1) rows and from each column factor out its first entry.

$$J = r^{N-1} \cos^{N-1} \theta_1 \cos^{N-2} \theta_2 \cdots \cos^{n} \theta_{N-1} \sin^{n} \theta_1 \sin^{n} \theta_2 \cdots \sin^{n} \theta_{N-1}$$

1 1 1 1 
$$\cot^{\theta}\theta$$

$$-\tan^{\theta}\theta$$

$$\cot^{\theta}\theta$$

Subtracting column 2 from column 1, column 3 from column 2, ..... column N from column N-1 there results

Since all entries in the upper left triangle are zero, the value of the determinant is easily found as minus one times the product of entries on the lower left to upper right diagonal.

(

$$J = r^{N-1} \cos^{N-1} \theta_1 \cos^{N-2} \theta_2 \cdots \cos^{n} \theta_{N-1} \sin^{n} \theta_2 \cdots \sin^{n} \theta_{N-1} \cos^{n} $

Notice that  $\tan \theta + \cot \theta = \frac{1}{\sin \theta \cos \theta}$ . Now upon simplifying we obtain

$$J = (-1)^{N_1N-1} \cos^{N_2} \cos^{N_3} \cos^{N_3} \cos^{N_2}$$

and 
$$|J| = r^{N-1} \cos^{N-2} \theta_1 \cos^{N-3} \theta_2 \cdots \cos^{10} \theta_{N-2}$$
 since

$$\cos \theta_{i} > 0 \text{ for } -\pi/2 \le \theta_{i} \le \pi/2, i=1, 2, ... \ 2.$$

In spherical coordinates the volume V of the N-dimensional hypersphere of radius r<sub>o</sub> is readily evaluated.

$$v = \int_{\mathbf{r} < \mathbf{r}_{0}}^{\pi/2} \int_{\theta_{1} = \frac{\pi}{2}}^{\pi/2} \int_{\theta_{N-2} = \frac{\pi}{2}}^{\pi/2} \int_{\theta_{N-1} = 0}^{N-1} \cos^{N-2}\theta_{1} \cos^{N-3}\theta_{2} ... \cos^{2}\theta_{N-2} drd\theta_{1} ... d\theta_{N-1}$$

Separating the integrations,

$$r_{o} = \frac{\pi}{2}$$

$$V = \int r^{N-1} dr \int cos^{N-2} \theta_{1} d\theta_{1} ... \int cos^{2}_{N-2} d\theta_{N-2}$$

$$r=0 \qquad \theta_{1} = -\frac{\pi}{2}$$

$$\theta_{N-1} = 0$$

Since 
$$\int \cos^{N}\theta d\theta = \frac{\Gamma\left(\frac{N+1}{2}\right)\Gamma\left(\frac{1}{2}\right)}{\Gamma\left(\frac{N+2}{2}\right)},$$

$$\theta = -\frac{\pi}{2}$$

$$V = \frac{r_o^N}{N} \quad \left[ \frac{\Gamma\left(\frac{N-1}{2}\right)\Gamma\left(\frac{1}{2}\right)}{\Gamma\left(\frac{N-1}{2}\right)} \right] \left[ \frac{\Gamma\left(\frac{N-2}{2}\right)\Gamma\left(\frac{1}{2}\right)}{\Gamma\left(\frac{N-1}{2}\right)} \right] \quad \dots \quad \left[ \frac{\Gamma\left(\frac{2}{2}\right)\Gamma\left(\frac{1}{2}\right)}{\Gamma\left(\frac{3}{2}\right)} \right] 2^{\pi}$$

$$= \frac{r_{o}^{N}}{N} 2^{\pi} \frac{\Gamma\left(\frac{1}{2}\right)^{N-2}\Gamma\left(\frac{1}{2}\right)}{\Gamma\left(\frac{N}{2}\right)}$$

But 
$$\Gamma\left(\frac{1}{2}\right) = \pi^{1/2}$$
 and  $\Gamma(1) = 1$ 

$$V = \frac{r_o^N}{N} \quad \frac{2^{\pi \pi^2}}{\Gamma(\frac{N}{2})} = \frac{2 r_o^N}{N} \quad \frac{\frac{N}{2}}{\Gamma(\frac{N}{2})}$$

## 11.2 Suitable Functions for Ellipsoidally Symmetric Distribution.

Suppose f is a real function, defined on domain R, a subset of  $[0, \infty]$ , and satisfying  $f(\mu) \ge 0$  for all  $\mu$  in R and  $\mu^k f(\mu) d$  is finite for  $k \le N+1$ . We show that f is suitable for defining a ellipsoidally symmetric density function and we determine the constant c so that of  $(\sqrt{x^*Ax})$  is an ellipsoidally symmetric density.

Let A be a NXN symmetric positive definite matrix and X an NX1 vector. Consider the ellipsoidally symmetric function  $f(\sqrt{x' Ax})$ . We wish to determine a constant C such that of  $(\sqrt{x' Ax})$  is a density function.

It is clear that 
$$C = \frac{1}{\int ... \int f \sqrt{x^i Ax} dx_1 ... dx_N}$$
.

To determine the value of the integral, we will make a transformation which rotates and scales. Let T be an orthonormal matrix such that T'AT = D, where D is a diagonal matrix. Make the change of variables

$$X = TD^{\frac{-1}{2}} z.$$

The Jacobian J of this transformation is

$$\frac{\partial x_1}{\partial z_1} \quad \frac{\partial x_2}{\partial z_1} \qquad \frac{\partial x_N}{\partial z_1} \\
\frac{\partial x_1}{\partial z_2} \quad \frac{\partial x_2}{\partial z_2} \qquad \frac{\partial x_N}{\partial z_2} \\
= ||TD^{-1/2}|| = ||T|||D||^{-1/2}$$

$$\frac{\partial x_1}{\partial z_1} \quad \frac{\partial x_2}{\partial z_2} \qquad \frac{\partial x_N}{\partial z_2} \\
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\frac{\partial x_1}{\partial z_2} \quad \frac{\partial x_1}{\partial z_2} \qquad \frac{\partial x_$$

Since T is an orthornormal matrix, |T| = 1 and

$$|D| = |T'AT| = |T'| |A| |T| = |A|$$
.

So the Jacobian is the determinant  $|A|^{-1/2}$  which is positive since A is positive definite.

$$I = \int \dots \int f(\sqrt{x'Ax}) dx_1 \dots dx_N$$

$$\sqrt{x'Ax} \in \mathbb{R}$$

$$= |A|^{-1/2} \int \dots \int f(\sqrt{z'D^{-1/2}T'ATD^{-1/2}z}) dz_1 \dots dz_N$$

$$\sqrt{z'D^{-1/2}T'ATD^{-1/2}z} \in \mathbb{R}$$

$$= |A|^{-1/2} \int \dots \int f(z'z) dz_1 \dots dz_N$$

$$\sqrt{z'z} \in \mathbb{R}$$

Now change to spherical coordinates.

$$z_1 = r \cos\theta_1 \cos\theta_2 \cdots \cos\theta_{N-1}$$
 $z_2 = r \cos\theta_1 \cos\theta_2 \cdots \cos\theta_{N-2} \sin\theta_{N-1}$ 
 $z_j = r \cos\theta_1 \cdots \cos\theta_{N-j} \sin\theta_{N-j+1}$ 
 $z_N = r \sin\theta_1$ 

The Jacobian of this transformation is  $(-1)^{-1} \cdot N^{-1} \cos^{N-2}\theta_1 \cos^{N-2}\theta_2 \cdots \cos^{n}N^{-2}$ .

$$\pi/2 \qquad \pi/2$$

$$= |A|^{-1/2} \int_{r}^{N-1} \int_{f(r)dr}^{N-1} \int_{cos}^{N-2} \int_{1}^{d\theta_{1}} \int_{cos}^{N-3} \int_{2}^{d\theta_{2}} cos^{N-3} \int_{2}^{d\theta_{2}} cos^{N-$$

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Since 
$$\int_{\cos\theta}^{\infty} \cos\theta d\theta = \frac{\Gamma\left(\frac{N+1}{2}\right) \Gamma\left(\frac{1}{2}\right)}{\Gamma\left(\frac{N+2}{2}\right)}$$
, the integrals are readily evaluated.

$$I = |A|^{-1/2} \int_{\Gamma} r^{N-1} f(r) dr \qquad \left[ \frac{\Gamma\left(\frac{N-1}{2}\right) \Gamma\left(\frac{1}{2}\right)}{\Gamma\left(\frac{N}{2}\right)} \frac{\Gamma\left(\frac{N-2}{2}\right) \Gamma\left(\frac{1}{2}\right)}{\Gamma\left(\frac{N-1}{2}\right)} \cdots \frac{\Gamma\left(\frac{2}{2}\right) \Gamma\left(\frac{1}{2}\right)}{\Gamma\left(\frac{3}{2}\right)} \right]^{2\pi}$$

$$= |A|^{-1/2} \int_{\mathbf{f}} f^{N-1} f(\mathbf{r}) d\mathbf{r} \qquad \frac{\Gamma(\frac{1}{2})}{\Gamma(\frac{n}{2})} \quad 2\pi$$

$$= \frac{2(\pi)^{N/2}}{|A|^{1/2} \Gamma(\frac{N}{2})} \int_{r \in \mathbb{R}} r^{N-1} f(r) dr$$

Therefore, the constant c is

( )

$$c = \frac{|A|^{+1/2} \Gamma\left(\frac{N}{2}\right)}{2 (\pi)^{N/2} \int_{r \in \mathbb{R}}^{N-1} f(r) dr}.$$

REPRODUCIBILITY OF THE ORIGINAL PAGE IS POOR Next we determine the normalizing constant c for the forms  $e^{-\frac{1}{2}u^2}$  and  $(1+u^2)^{-m}$ 

### Case 1. Multivariate Normal

The density function for the multivariate normal distribution is of the form

$$f(\sqrt{x^{T}Ax}) = e^{-\frac{1}{2}x^{T}Ax}, \quad o \leq x^{T}Ax \leq \infty$$
or, 
$$f(r) = e^{-\frac{1}{2}r^{2}}, \quad o \leq r \leq \infty$$

Since 
$$\int_{r \in R} r^{N-1} f(r) dr = \int_{0}^{\infty} r^{N-1} e^{-\frac{1}{2}r^{2}} dr = \int_{0}^{\infty} (2u)^{\frac{N-2}{2}} e^{-u} du = 2^{\frac{N-2}{2}} \Gamma \left(\frac{N}{2}\right)$$
then the normalizing constant is

$$c = \frac{\Gamma\left(\frac{N}{2}\right)}{2\pi^{\frac{N}{2}}|A|^{-\frac{1}{2}}\int_{\Gamma}r^{N-1}f(r)dr} = \frac{\frac{N}{2}\frac{N}{2}}{2\pi^{\frac{N}{2}}|A|^{-\frac{1}{2}}2^{\frac{N}{2}-1}\Gamma\left(\frac{N}{2}\right)}$$

$$= \frac{1}{(2\pi)^{\frac{N}{2}}|A|^{\frac{1}{2}}}$$
and,
$$f(\sqrt{x^{i}Ax}) = \frac{1}{(2\pi)^{\frac{N}{2}}|A|^{-\frac{1}{2}}} e^{-\frac{1}{2}x^{i}Ax}, o \leq x^{i}Ax \leq \infty.$$

$$(2\pi)^{\frac{N}{2}}|A|^{\frac{1}{2}}$$

Case 2. Multivariate Pearson Type VII.

then, 
$$\int_{r}^{N-1} f(r) dr = \int_{o}^{\infty} r^{N-1} (1+r^2)^{-m} dr = \int_{o}^{1} \frac{1-u}{u} \frac{N-2}{2} u^m \frac{du}{2u^2}$$

$$= \frac{1}{2} \frac{\Gamma\left(\frac{N}{2}\right) \Gamma\left(m-\frac{N}{2}\right)}{\Gamma\left(m\right)} , m > \frac{N}{2}.$$
And the normalizing constant is

3

$$c = \frac{\Gamma\left(\frac{N}{2}\right) - \Gamma\left(m\right)}{2\pi^{\frac{N}{2}} |A|^{-\frac{1}{2}} + \frac{1}{2}\Gamma\left(\frac{N}{2}\right)\Gamma\left(m - \frac{N}{2}\right)} = \frac{\Gamma\left(m\right)}{\pi^{\frac{N}{2}} |A|^{-\frac{1}{2}} + \Gamma\left(m - \frac{N}{2}\right)}$$

and, 
$$f(\sqrt{x^*Ax}) = \frac{\Gamma(m)|A|^{\frac{1}{2}}}{\frac{N}{\pi}\Gamma(m^{-\frac{N}{2}})}$$
  $(1+x^*Ax)^{-m}$ ,  $m > \frac{N}{2}$ ,  $o \le x^*Ax \le \infty$ .

## II.3 Covariance Matrix For Multivariate Distributions.

Given the density function  $f(\sqrt{x^iAx})$  we want to find the covariance matrix  $\ddagger$ ,

0

$$\ddagger = E(xx') = c \int ... \int xx' f(\sqrt{x'Ax}) dx_1 ... dx_N$$

$$\sqrt{x'Ax} \in \mathbb{R}$$

where c is a normalizing constant and N is the dimension of x. Using the orthonormal transformation T'AT = D, where D is a diagonal matrix, and scaling with  $x=TD^{-\frac{1}{2}}z$ ,

since  $z'AX = z'D^{-\frac{1}{2}}T'ATD^{-\frac{1}{2}}z = z'D^{-\frac{1}{2}}DD^{\frac{1}{2}}z = z'z$ 

and
$$J = \begin{vmatrix} \frac{\partial x_1}{\partial z_1} & \frac{\partial x_N}{\partial z_1} \\ \frac{\partial x_1}{\partial z_1} & \frac{\partial x_N}{\partial z_1} \\ \frac{\partial x_1}{\partial z_1} & \frac{\partial x_N}{\partial z_1} \end{vmatrix} = |T D^{\frac{1}{2}}| = |T| |D|^{\frac{1}{2}} = |D|^{-\frac{1}{2}} = |T'AT|^{-\frac{1}{2}} = |A|^{\frac{1}{2}}.$$

Rearranging,  $z = c |A|^{-\frac{1}{2}} T D^{-\frac{1}{2}} \int \dots \int z z' f(\sqrt{z'z}) dz_1 \dots dz_N D^{-\frac{1}{2}} T',$   $\sqrt{z'z} \in \mathbb{R}$ 

where z'z is an N x N matrix. Looking at the off diagonal terms, for  $i \neq j$ ,  $\int \cdot \cdot \cdot \int z_i z_j f(\sqrt{z_i z_j}) dz_1 \cdot \cdot \cdot dz_N = 0$  since we are integrating an odd

function over even limits.

For terms of 
$$z$$
 along the diagonal , for  $i=j$ , 
$$\int \dots \int_{z_1^2} z_1^2 f(\sqrt{z^2z}) dz_1 \dots dz_N = \int \dots \int_{z_1^2} z_1^2 f(\sqrt{z^2z}) dz_1 \dots dz_N$$

$$\sqrt{z^2z} \in \mathbb{R}$$

and changing to spherical coordinates,

$$= \int \int_{r \in R_{-}\theta_{1}}^{\pi/2} \cdots \int_{r=\pi/2}^{\pi/2} \int_{\theta_{N-2}}^{2\pi} \int_{r=\pi/2}^{2\pi} \int_{\theta_{N-1}=0}^{2\pi} \int_{\theta_{N-1}=0}^{\pi/2} \int_{\theta_{$$

$$= \int_{r} r^{N+1} f(r) dr \int_{0}^{\pi/2} \int_{0}^{N_{\theta}} 1^{d\theta} d\theta + \int_{0}^{\pi/2} \int_$$

Since 
$$\int_{-\pi/2}^{\pi/2} \cos^{k} \theta d\theta = \frac{\left[\frac{k+1}{2}\right]_{\Gamma}\left(\frac{1}{2}\right)}{\Gamma\left(\frac{k+2}{2}\right)},$$

then

$$\int \dots \int_{z_{1}}^{2} f(\sqrt{z^{T}z}) dz_{1} \dots dz_{N} = \int_{r}^{r} \int_{r}^{N+1} f(r) dr \frac{\Gamma\left(\frac{N+1}{2}\right)\Gamma\left(\frac{1}{2}\right)}{\Gamma\left(\frac{k+2}{2}\right)} \frac{\Gamma\left(\frac{N}{2}\right)\Gamma\left(\frac{1}{2}\right)}{\Gamma\left(\frac{N+1}{2}\right)} \dots \frac{\Gamma\left(\frac{4}{2}\right)\Gamma\left(\frac{1}{2}\right)}{\Gamma\left(\frac{4}{2}\right)} \frac{2 \frac{\Gamma\left(\frac{3}{2}\right)\Gamma\left(\frac{1}{2}\right)}{\Gamma\left(\frac{4}{2}\right)}}{\Gamma\left(\frac{4}{2}\right)}$$

$$= \frac{2\pi}{N} \frac{\frac{N}{2}}{\Gamma\left(\frac{N}{2}\right)} \int_{r}^{N+1} f(r) dr \cdot \frac{\Gamma\left(\frac{N}{2}\right)\Gamma\left(\frac{N}{2}\right)}{\Gamma\left(\frac{N}{2}\right)} \frac{\Gamma\left(\frac{N}{2}\right)}{\Gamma\left(\frac{N}{2}\right)} \frac{\Gamma\left(\frac{N}{2}\right)\Gamma\left(\frac{N}{2}\right)}{\Gamma\left(\frac{N}{2}\right)} \frac{\Gamma\left(\frac{N}{2}\right)\Gamma\left(\frac{N}{2}\right)}{\Gamma\left(\frac{N}{2}\right)} \frac{\Gamma\left(\frac{N}{2}\right)}{\Gamma\left(\frac{N}{2}\right)} \frac{\Gamma\left(\frac{N}{2}\right)}{\Gamma\left(\frac{N}{2}\right)} \frac{\Gamma\left(\frac{N}{2}\right)}{\Gamma\left(\frac{N}{2}\right)} \frac{\Gamma\left(\frac{N}{2}\right)}{\Gamma\left(\frac{N}{2}\right)} \frac{\Gamma\left(\frac{N}{2}\right)}{\Gamma\left(\frac{N}{2}\right)} \frac{\Gamma\left(\frac{N}{2}\right)}{\Gamma\left$$

From II.2,
$$c = \frac{\Gamma\left(\frac{N}{2}\right) |A^{\frac{1}{2}}}{2\pi^{\frac{N}{2}} \int_{\Gamma}^{N-1} f(r) dr}$$

$$r \in \mathbb{R}$$

where 
$$T' AT = D$$
, or  $D^{-1} = T' A^{-1}T$ .

So that 
$$\Sigma = A^{-1}$$
  $\frac{\int_{r}^{r} N^{+1} f(r) dr}{\sqrt{\int_{r}^{r} N^{-1} f(r) dr}}$ 

Since the integrals are constants for any f, the covariance matrix is directly proportional to A<sup>-1</sup>. We determine the constant of proportionality for the multivariate normal and Pearson Type VII distributions.

Case 1. Multivariate Normal

For the multivariate normal, the density is of the form  $f(r) = ce^{-\frac{1}{2}r^2}$  where

Since, 
$$\int_{2}^{\infty} r^{k} e^{-\frac{1}{2}r^{2}} dr = 2^{\frac{k-1}{2}} \Gamma\left(\frac{k+1}{2}\right)$$

then 
$$\int r^{N+1} f(r) dr = c 2^{\frac{N}{2}} \Gamma \left( \frac{N+2}{2} \right)$$

and 
$$\int r^{N-1} f(r) dr = c2^{\frac{N-2}{2}} \Gamma(\frac{N}{2})$$

so that 
$$\ddagger = A^{-1} \frac{2^{\frac{N}{2}} \frac{N}{2} \Gamma^{\frac{N}{2}}}{N 2^{\frac{N}{2}-1} \Gamma^{\frac{N}{2}}}$$

and thus, 
$$= A^{-1}$$

or, 
$$A = \frac{1}{2}$$
.

Case 2 Multivariate Pearson Type VII.  

$$f(r) = c(1+r^2)^{-m}$$
,  $o \le r \le \infty$ .

Since 
$$\int r^{N+1} f(r) dr = \frac{c}{2} \frac{\Gamma(\frac{N}{2} + 1)\Gamma(m-\frac{N}{2} - 1)}{\Gamma(m)}$$

and 
$$\int r^{N-1} f(r) dr = \frac{c}{2}$$
  $\frac{r(\frac{N}{2})}{r(m)} \frac{r(\frac{N}{2})}{r(m)}$ 

then, 
$$\ddagger = A^{-1} \qquad \frac{\frac{cN}{2} \Gamma\left(\frac{N}{2}\right) \Gamma\left(\frac{N}{m-2-1}\right)}{2N c \Gamma\left(m\right)} \qquad \frac{2 \Gamma\left(m\right)}{c \Gamma\left(\frac{N}{2}\right) \left(m-\frac{N}{2}-1\right) \Gamma\left(m-\frac{N}{2}-1\right)}$$

$$= A^{-1} \frac{1}{2 \left(m - \frac{N}{2} - 1\right)}$$

## APPENDIX III

# NORMALIZATION PROCEDURE TO MAKE COVARIANCE MATRIX INVARIANT UNDER TRANSLATING AND SCALING TRANSFORMATIONS

Let  $\frac{1}{x}$  be a covariance matrix for the difference vectors of grey tone N-tuples in a specified spatial relationship within a subimage. We transform the covariance matrix to obtain the normalized covariance matrix  $\frac{1}{y}$  using y = Dx, where x is the difference vector and D is diagonal. Thus, assuming zero mean,

For normalization, we have

$$d_{ii} = \frac{1}{\sqrt{\sigma_{ii}}}$$

where  $\sigma_{ii}$  is the ii<sup>th</sup> element of  $\frac{1}{x}$  and is the variance  $\sigma_{i}^{2}$  of the i<sup>th</sup> component of x.

Assume that all grey tone N-tuples have a scale factor a and an additive factor a so that for N-tuples  $ax_1 + a$  and  $ax_2 + a$ , the difference becomes

$$y = (ax_1 + c) - (ax_2 + c)$$
  
 $y = a(x_1 - x_2).$ 

Hence, translational effects due to bias terms are cancelled but scaling effects are marked by the diagonal transformation y = Ax so that the elements of the covariance matrix become

where A is a diagonal matrix. We must show that  $\ddagger_N$ , the normalized covariance matrix of  $\ddagger$ , is identical to  $\ddagger_y$ . Normalizing  $\ddagger$  we have

$$\ddagger_N = D\ddagger D$$

$$= D (A \ddagger_x A) D$$

where D is again diagonal but in this case,

$$d_{ii} = \frac{1}{\sqrt{\sigma_{ii} \sigma_{ii}^2}}$$

with a; the iith element of diagonal matrix A. For the ijth element of ‡N we have

$$\sigma_{\text{Nij}} = d_{\text{ii}} a_{\text{ii}} \sigma_{\text{ij}} a_{\text{jj}} d_{\text{jj}}$$

$$= \frac{\sigma_{\text{ii}} \sigma_{\text{ij}} a_{\text{jj}}}{\sqrt{\sigma_{\text{ii}} a_{\text{ii}}^2} \sqrt{\sigma_{\text{jj}} \sigma_{\text{jj}}^2}}$$

$$= \sigma_{\text{ij}},$$

Thus, this procedure of normalization makes the entries of the normalized covariance matrix invariant with respect to translating and scaling transformations on the grey tone N-tuples.

# APPENDIX IV COMPUTER PROGRAM DOCUMENTATION & LISTINGS

# IV.1 PROGRAM DOCUMENTATION

IV.1-a ERTS Retrieval Programs
 IV.1-b Texture Analysis Programs
 IV.1-c Cross-Band Texture Analysis Programs
 IV.1-d Piecewise Linear Classification Programs

# IV.2 PROGRAM LISTINGS

IV.2-a ERTS Retrieval Programs
 IV.2-b Texture Analysis Programs
 IV.2-c Cross-Band Texture Analysis Programs
 IV.2-d Piecewise Linear Classification Programs



# IV.1-a ERTS Retrieval Programs - Documentation

RETV

ERTS

PIXEY

ZEQUAN

**PITCHR** 

WRTDSK

RDDSK1

KEQUAN

RDDSK2

#### ERTS RETRIEVAL PROGRAMS

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PROGRAM TITLE:

RETV

**VERSION:** 

. I

DATE:

January, 1974

UPDATE:

January, 1974

AUTHOR:

Robert J. Bosley

DOCUMENTED BY:

Robert J. Bosley

PROGRAM LANGUAGE:

FORTRAN IV

IMPLEMENTED ON:

HW635

**PURPOSE:** 

This is the mainline for the ERTS Retrieval Programs which retrieve ERTS MSS data from standard NASA digital tapes and outputs the image data in a picture, or greytone listing, or copies it onto an output tape.

# INPUT PARAMETERS under NAMELIST 'PARAM':

NBAND

Band number, 1 through 4 for MSS band 4

through 7, to be selected. Set to 5 for all

4 bands, assumed to be 2.

IRSTRT,

Row, column starting coordinates.

ICSTRT

Row, column stopping coordinates.

ICSTOP TITLE

80 Column title for output list.

MILLI

TRUE if coordinates are in millimeters;

assumed to be FALSE, coordinates are row,

column points in ERTS image.

SMALL

TRUE if millimeter coordinates are from a small

70 mm by 70 mm negative; assumed to be FALSE, coordinates from a 7 inch by 7 inch

print.

PRNT

TRUE for grey tone listing; assumed FALSE.

TAPE

TRUE for tape output; assumed FALSE.

IFIL

Output file code for tape; assumed to be 02.

PIC

TRUE for picture output; assumed TRUE.

QUAN

TRUE for equals probability quantizing of the

image; assumed to be TRUE.

SPIC

TRUE for special picture run-see PIXEY;

assumed to be FALSE.

## REQUIREMENTS:

1. ERTS input tape must be on file code 'ES'.

2. Four disc files must be on files 11, 12, 13 and 14.

3. Any output tape must be positioned on file code 'IFIL'.

All coordinates must be determined relative to the input tape rather than the print — that is, ICSTOP must not exceed 824 points or 46 mm.

5. Core - 22 k

6. Subprograms required:

**RETV** 

**ERTS** 

PIXEY

ZEQUAN

**ERTS** 

**PITCHR** 

**WRTDSK** 

**RDDSKI** 

KEQUAN

**PITCHR** 

RDDSK2

#### **COMMENTS:**

For efficiency, data is read by RETV in blocks of 41 lines by 41 points. One ERTS tape (one-fourth of an image) will then be covered by 20 horizontal blocks, leaving 4 points left at the end of each line. Note --- sometimes on the first tape of an image, the first four points are greytones of 255 and can adversely affect a picture printout. If so, set ICSTRT = 5.

Also note that if the point ICSTRT is not a multiple of 41 from the end of the line, then the last points may not necessarily be listed since blocks are determined starting from ICSTRT.

A special picture run can be made to print out and reduce any image over the entire tape by setting SPIC to TRUE and specifying under namelist PARAM the following parameters: IRSTRT, IRSTOP, ICSTRT, ICSTOP, NBAND, QUAN. Then under namelist PICTUR, parameters for PITCHR are specified. See PIXEY for details.

## ERTS RETRIEVAL PROGRAM

SUBPROGRAM TITLE:

**ERTS** 

VERSION:

11

DATE:

September, 1972

**UPDATE:** 

November, 1973

AUTHOR:

G. Gunnels

DOCUMENTED BY:

R. Bosley

PROGRAM LANGUAGE:

GMAP

IMPLEMENTED ON:

HW635

PURPOSE:

To read 7-track ERTS MSS data tapes.

ENTRY POINTS:

CALL EINIT (NOLS)

CALL ESKIP (NOSK)

CALL EREAD (I, LN)

REFEODUCIBILITY OF THE ORIGINAL PAGE IS POOR

CALL EREWIND

ARGUMENTS:

NOLS

Number of words per scan line; returned by EINIT.

NOSK

The number of records to skip.

I

The array into which the NOLS words of data

from a line of ERTS data is placed.

LN

Returned by EREAD giving the line number of the

line of data returned. If LN =0, the end of file

was reached on the ERTS tape.

**ERROR FLAGS:** 

MB

EREAD buffer is not large enough for a block of

FRTS data.

AI

EINIT was called twice.

NI

EINIT was not called before calling EREAD,

ESKIP, or EREWND.

UE

EOF encountered while reading ID or

annotation blocks on ERTS tape.

EF .

EOF encountered while trying to skip records

in ESKIP.

### COMMENTS:

EINIT initializes the ERTS tape so that data may be read, and must be called first. ESKIP skips over NOSK records (scan lines). EREWND rewinds the ERTS tape. EINIT must not be called twice. The data placed into array I by EREAD is in standard corresponding point forms. Since the ERTS MSS data has four channels, there are actually NOLS/4 points or cells per scan line.

## REQUIREMENTS:

ERTS tape must be on file code 'ES'.

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### ERTS RETRIEVAL PROGRAMS

SUBPROGRAM TITLE:

PIXEY

**VERSION:** 

10

DATE:

January, 1974

UPDATE:

January, 1974

AUTHOR:

Robert J. Bosley

DOCUMENTED BY:

Robert J. Bosley

PROGRAM LANGUAGE:

FORTRAN IV

IMPLEMENTED ON:

HW635

PURPOSE:

To provide a flexible option for printing a picture of ERTS MSS

data using user specified parameters to PITCHR.

ENTRY POINT:

CALL PIXEY (ILINE, IMAGE, IRSTRT, IRSTOP, ICSTRT,

ICSTOP, QUAN, NBAND)

INPUT ARGUMENTS:

ILINE

Array the ERTS line is read into.

**IMAGE** 

Array containing one line of the image.

IRSTRT, IRSTOP Starting, stopping row in the image.

ICSTRT, ICSTOP Starting, stopping column in the image.

QUAN

TRUE for equal probability quantizing of

the image.

NBAND

Bond number to be processed; set to

5 for all 4 MSS bands.

INPUT PARAMETERS: under NAMELIST 'PICTUR':

LNSKIP,

Line and column increment for ERTS data;

KOLSKP

assumed to be 4,3.

ICELL, JCELL Number of rows, columns in image to be printed;

assumed to be 1,256.

INIT Number of times entry to PITCHR is made at

SNAP: must be greater than 1; assumed to be 304.

IMIN, IMAX Minimum, maximum greytones in image;

assumed to be 0,75 or 12 if QUAN is true.

NROW Number of rows to be printed; equal to ICELL.

NFILES Number of output files available to PITCHR;

set to 0 for all output on file code 06, set to 2

for files 06 and 42; assumed to be 2.

IFIL(10) Array containing output file codes; assumed

to be 06 and 42.

NULW, NULD Number of columns, rows per output page;

assumed to be 129, 60.

AMAG, DMAG Width, length magnification for output picture;

assumed to be 1.

SAMPLE RUN:

\$PARAM SPIC=T, QUAN=T, IRSTRT=1, IRSTOP=1216, ICSTRT=5, ICSTOP=772, NBAND=2\$END/\$PICTUR INIT=304, NFILES=2, LNSKIP=4, KOLSKP=3, JCELL=256\$END.

This run will print out on files 06 and 42 a picture 256 points wide by 304 lines long. Note that 1216/4 = 304 and 786/3 = 256 gives the values for LNSKIP=4, KOLSKP=3, JCELL=256, INIT=304. Also, using these values for LNSKIP and KOLSKP will result in a picture in proportion to the same area on an ERTS image print, approximately twelve 64 by 64 subimages across by 19 subimages down the tape.

COMMENTS:

If SPIC=T in the SPARAM card, then a SPICTUR card must follow.

Note that the parameters IRSTRT, IRSTOP, ICSTRT, ICSTOP,

QUAN, NBAND are supplied on the SPARAM card while LNSKIP,

KOLSKP and all PITCHR parameters are supplied on the SPICTUR

card.

The program will output a negative picture but a positive picture can be made by setting IMAX=0 and IMIN=75 (or 12 if quantization is used). The parameters are initialized to output an area approximately twelve 64 by 64 subimages wide by 19 down. For a complete description of PITCHR parameters, see PITCHR.

# REQUIREMENTS:

- 1. Processor time for one band with parameters as shown in the sample run is 0.075 hr with 3k lines of output.
- 2. Subprograms required are ZEQUAN, PITCHR.

## CALLED BY:

**RETV** 

# ERTS RETRIEVAL PROGRAM

SUBPROGRAM TITLE:

ZEQUAN

VERSION:

1

DATE:

September, 1973

**UPDATE:** 

September, 1973

AUTHOR:

Z. Dinstein

DOCUMENTED BY:

Robert J. Bosley

PROGRAM LANGUAGE:

FORTRAN IV

IMPLEMENTED ON:

HW635

PURPOSE:

To equal probability quantize a large image on disc to NQ levels.

ENTRY POINT:

CALL ZEQUAN (LINE, NUMLIN, NUMPPL, NCOMP, ICOMP,

LEFT, NQ, INFILE, IOUTFL)

INPUT ARGUMENTS:

LINE

Array to store one line of the image.

NUMLIN

Number of lines in the image.

NUMPPL

Number of columns in the image.

NCOMP

Number of components in the image.

ICOMP

The component to be quantized.

LEFT

Left-most cell desired in the line.

NQ

Number of quantized levels.

INFIL

File code of disc containing the image

to be quantized.

OUTPUT ARGUMENTS:

IOUTFL

Output file code for the quantized image.

# COMMENTS:

Processing is done line by line after an initial pass through the image is made to determine the number of grey tone levels in the image. The minimum and maximum grey tones are printed. The number of grey tone levels should not exceed 512. Input data on disc INFILE must be in binary.

CALLED BY:

PIXEY

G

# ERTS RETRIEVAL PROGRAM

SUBPROGRAM TITLE:

PITCHR

**VERSION:** 

II

DATE:

July, 1969

UPDATE:

November, 1970

AUTHOR:

R. Cowles

DOCUMENTED BY:

G. Elliott

PROGRAM LANGUAGE:

**GMAP** 

IMPLEMENTED ON:

HW635

PURPOSE:

To print out images in 13 grey levels.

ENTRY POINTS:

CALL PITCHR (IRRAY, ICELL, JCELL, INIT, IT, IMIN, IMAX,

NROW, NFIL, IFIL, NULW, NULD, AMAG, DMAG, \*)

CALL SNAP

CALL SNAPA (IARRAY)

CALL ENDBNR

ARGUMENTS:

**IRRAY** 

Array to be printed, either integer or floating

point.

**ICELL** 

Number of rows in array. (row dimension)

JCELL

Number of columns in array. (column dimension)

INIT

=0 if all of image to be printed out is in core

at time of call. Output will be done before

return to calling program.

=1 for reinitialization entry. Any of the arguments

previously specified with INIT = 0 with the

exception of INIT may now be changed. Return

will be made to the calling program without

any output. This is especially useful if the image

is read into core in pieces and the last piece

does not completely fill the array. >1 for initialization

entry. INIT will reflect the number of times entry is made at SNAP before final border is to be printed. Return is to the calling routine without any output.

INIT =0 is assumed.

=0 if array is floating point

11

NULW

=1 if array is integer

| | = | | is assumed.

IMIN Minimum brightness level in array. Type of

IMIN should correspond to that indicated by II.

IMIN =0 is assumed.

IMAX Maximum brightness level in array. Type of IMAX

should correspond to that indicated by 11.

IMAX =12 is assumed.

NROW Number of rows of array to be printed if full array

is not to be printed. This allows for partial printing.

NROW = ICELL is assumed.

NFIL Number of output files available if image is to

be output in strips that are NULW lines wide.

=0 for all output on file code 06

=1 for all output on file code IFIL

1 for outputs in strips, on file codes specified

in array IFIL. NFIL=0 is assumed.

IFIL Array containing output file codes. Ignored unless

NFIL = 0. IFIL must be a variable rather than a

literal, since SNAP alters the value(s) of IFIL to contain the location of the relevant file

control block in the upper half of the word.

Number columns per output page. MAX =129

NULW = 120 unless otherwise specified.

NULD Number of rows to be printed before a slew on the

top of the next page is given. NULD = ICELL\*DMAG +1.

AMAG

Floating point magnification in width.

AMAG = 1 is assumed.

**DMAG** 

Floating point magnification in length,

DMAG = 1 is assumed.

\*

Error return if not enough output files are available. Return is made with NARG =-10. If not specified, a message will be printed out on the accounting report and an NF report will terminate execution.

#### ERTS RETRIEVAL PROGRAMS

SUBPROGRAM TITLE:

WRTDSK

VERSION:

H

DATE:

September, 1972

**UPDATE:** 

January, 1974

AUTHOR:

Robert J. Bosley

DOCUMENTED BY:

Robert J. Bosley

PROGRAM LANGUAGE:

FORTRAN IV

IMPLEMENTED ON:

HW635

PURPOSE:

To write one line of ERTS data onto disc files, one file for each band.

**ENTRY POINT:** 

CALL WRTDSK (ILINE, NHOR, IPSTR, IPEND, NBAND)

INPUT ARGUMENTS:

ILINE

Array containing one line of ERTS data

**NHOR** 

Number of horizontal blocks of 41 columns

in the line.

IPSTR, IPEND

Starting and ending points in the ERTS line.

NBAND

The desired band; set to 5 for all 4 MSS

bands.

COMMEN(S:

After reading a line of data into ILINE, RETV calls WRTDSK to pick out the segment of NHOR blocks in the line and write it onto disc. If only one band is desired, only that band is put onto disc. Disc files 11, 12, 13, and 14 must be present.

CALLED BY:

**RETV** 

## ERTS RETRIEVAL PROGRAMS

SUBPROGRAM TITLE:

**RDDSKL** 

RELEGIOUS MATY OF THE

**VERSION:** 

11

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September, 1972

UPDATE:

DATE:

January, 1974

**AUTHOR:** 

Robert J. Bosley

DOCUMENTED BY:

Robert J. Bosley

PROGRAM LANGUAGE:

FORTRAN IV

IMPLEMENTED ON:

HW635

PURPOSE:

To read the ERTS data from disc and print out a picture of the image, proceeding vertically and then from left to right.

ENTRY POINT:

CALL RDDSKL (IMAGE, QUAN, NHOR, NVERT, NDSK)

INPUT ARGUMENTS:

IMAGE

Array used to store two 41 x 41 blocks.

QUAN

TRUE for equal probability quantization of the

image.

NHOR

Number of horizontal 41 x 41 blocks.

**NVERT** 

Number of vertical 41 x 41 blocks.

NDSK

File code of disc to be processed.

ERROR FLAGS:

Same as for PITCHR.

COMMENTS:

Since blocks are 41 columns wide, then two horizontal blocks are processed together, except for the final strip of blocks when NHOR is an odd number. It is recommended that QUAN be set to true since transmission errors result in very high and very low greytones along the line which will make the true image features indistinguishable unless equal probability quantizing is used.

SUBPROGRAMS CALLED:

KEQUAN

(

PITCHR

CALLED BY:

RETV

# ERTS RETRIEVAL PROGRAMS

SUBPROGRAM TITLE:

**KEQUAN** 

MERSION:

II

DATE:

September, 1971

**UPDATE:** 

June, 1973

**AUTHOR:** 

G. Elliot

DOCUMENTED BY:

Robert J. Bosley

PROGRAM LANGUAGE:

FORTRAN IV

IMPLEMENTED ON:

HW635

PURPOSE:

To equal probability quantize the input array to NQ levels.

ENTRY POINT:

CALL KEQUAN (IA, NGL, NQ, IASIZE)

ARGUMENTS:

IA

Input array which is returned quantized.

NGL

Number of greytone levels in IA.

NQ

Number of quantizing levels.

IASIZE

Size of array IA.

ERROR FLAGS:

If the number of greytone levels exceeds 512, an error message

is printed.

CALLED BY:

RDDSK1

#### ERTS RETRIEVAL PROGRAMS

SUBPROGRAM TITLE:

RDDSK2

REPRODUCIBILITY OF THE ORIGINAL PAGE IS FOOR

VERSION:

II

DATE:

September, 1972

UPDATE:

January, 1974

AUTHOR:

Robert J. Boiley

DOCUMENTED BY:

Robert J. Busley

PROGRAM LANGUAGE:

FORTRAN IV

IMPLEMENTED ON:

HW635

PURPOSE:

To read ERTS data from disc and print out the grey tones and/or copy the data onto an output tape.

# ENTRY POINT:

CALL RDDSK2 (IMAGE, IRSTRT, IRSTOP, NHOR, NDSK, PRNT, TAPE, IFIL)

#### INPUT ARGUMENTS:

IMAGE

Array data is read into.

IRSTRT, IRSTOP Starting, stopping lines of data.

NHOR

Number of horizontal blocks of 41 columns.

NDSK

File code of the disc to be read.

PRINT

TRUE for greytone listing.

TAPE

TRUE for tape output

IFIL

Output tape file code.

#### COMMENTS:

If neither the grey tone listing nor the output tape is desired, execution is returned to the calling program, RETV.

CALLED BY:

RETV

# IV.1-b Texture Analysis Programs - Documentation

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S

MAINLN
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PITCHR
FPLXIT
INDEX
IMOMTR
COR
IEQPQ1
RITOWT

# ERTS TEXTURE ANALYSIS

PROGRAM TITLE:

MAINLN

VERSION:

11

DATE:

September, 1972

UPDATE:

June, 1973

**AUTHOR:** 

Robert J. Bosley

DOCUMENTED BY:

Craig Paul

PROGRAM LANGUAGE:

FORTRAN IV

IMPLEMENTED ON:

HW 635

PURPOSE:

To read the Texture Analysis parameters, read in subimages from ERTS input tape, and send these subimages to MAING for processing.

# INPUT PARAMETERS:

1. Title Card: Up to 80 columns for use as identification information.

2. Parameters under NAMELIST /PARAM/:

IBAND

Band used for processing-

= 1 for MSS Band 4

= 2 for MSS Band 5

= 3 for MSS Band 6

= 4 for MSS Band 7

assumed to be 2.

NUMPPL

Number of points per line of each subimage;

assumed to be 64.

NUMLIN

Number of lines of each subimage; assumed

to be 64.

NBVERT

Number of the last vertical subimage to be

processed; assumed to be 36.

NUMIM

Number of subimages taken horizontally in

one run; assumed to be 3. Note:

NUMPPL x NUMIM must not exceed 192 points.

N

N11 The upper-left column coordinate for the vertical strip (of NUMIM horizontal

subimages) being processed in this run.

NUMSTR The number of the vertical strip being processed;

assumed to be 1.

NBSKIP The number of vertical rows of subimages to

skip before beginning processing; assumed to

be 0.

PNCH Specifies the output option:

= 1HY for card output

= 1HT for tape output on file code IF

= 1HN for neither card nor tape but a listing
 of the LEX arrays; assumed to be tape (1HT).
 Note: PNCH must be denoted as a Hollerith

constant in the \$PARAM card.

. IF Output tape file code which is assumed to be

in position (it is not rewound); assumed to be 1031.

NRED The base used for image reduction; assumed

to be 1.

NSTART, Each subimage is processed NSTART through

NTIMES NTIMES times, each time with a new reduction

factor NFT = NRED \*\* NLAYER where NLAYER

goes from NSTART -1 through NTIMES -1;

both assumed to be 1.

PICTUR TRUE for a picture of each subimage; assumed

FALSE.

NQUANT Number of quantization levels of the probability

function in IMOMTR; assumed to be 16.

MERGE TRUE for all four LEX arrays to be merged into

one array; assumed to be TRUE.

#### REQUIREMENTS:

- 1. ERTS input tape must be on file code 'ES'.
- 2. Core 43k.
- 3. Disc file must be on file code '02'.
- 4. Subprograms required:

MAINLN

**ERTS** 

MAING

**KEQUAN** 

PITCHR

**FPLXIT** 

**INDEX** 

**IMOMTR** 

**INDEX** 

COR

IEQPQ1

RITOWT

# CARD SETUP FOR SAMPLE RUN:

\$ IDENT 9999, ANYNAME

\$ LIBRARY LB

\$ OBJECT ERTS TEXTURE ANALYSIS PROGRAMS

\$ DKEND

**\$** EXECUTE

\$ PRMFL LB, R, S, PATTERN/GEE/LIB

\$ TAPE ES, A5DD, 60500, ERTSOO, INPUT

\$ FILE 02, A2R, 2L

\$ LIMITS 20, 43k,,10k

\$ INCODE IBMF

TEST-SETUP FOR TEXTURE ANALYSIS PROGRAMS

\$ PARAM N11=1, PNCH = 1HN, PICTUR = T\$END

\$ ENDJOB

This run of the texture analysis programs will process the ERTS image in  $64 \times 64$  subimages, giving only printed output plus a picture of each subimage.

### COMMENTS:

This is the mainline of the texture analysis programs. Each ERTS image is divided into 4 vertical strips, each put onto a 7-track digital tape. This image is divided up into subimages for processing. For example, if the subimages are 64 columns by 64 lines, then the first tape contains subimages 1 through 12, the second contains 13 through 24, and so on up to 48 horizontal subimages. And, each tape contains 36 vertical subimages. Often, the first 8 points at the beginning of each line have grey tones of 255 and will adversely affect processing. Therefore, the first eight points of each line are skipped. Each tape contains usually 3296 points of 4 bands, or 824 points per line for one band. Skipping the first eight points leaves 816 points per line. If subimages are each 64 columns, then 12 will occupy 768 columns, leaving 48 points at edge of each tape unused.

Due to core limitations, each input tape is processed in vertical strips of up to 192 horizontal points. This is 3,64 by 64 subimages, or 6,32 by 32 subimages in one run. For example, if NUMPPL = 64 and NUMIM =3, then the tape is processed as follows: Run 1 - (1, 1), (1, 2), (1, 3), (2, 1), (2, 2), (2, 3), (3, 1),..., (36, 1) (36, 2), (36, 3). Run 2 - (1, 4), (1, 5), (1, 6), (2, 4), (2, 5), (2, 6), (3, 4),..., (36, 4), (36, 5), (36, 6). Run 3 - (1, 7), (1, 8), (1, 9), (2, 7), (2, 8), (2, 9), (3, 7),..., (36, 7), (36, 8), (36, 9). Run 4 - (1, 10), (1, 11) (1, 12),..., (36, 10), (36, 11), (36, 12). This completes the processing of the first tape. Note that N11 is determined relative to the entire image while NUMSTR is relative to the input tape. That is, for tape 1, N11 and NUMSTR are both 1 for Run 1. But for Run 2, N11 is 4 while NUMSTR is 2 and for Run 3, N11 is 7 while NUMSTR is 3, etc.

Continuing with the example, tope 2 will be processed as follows: Run 1 (N11= 13, NUMSTR=1) - (1, 13), (1, 14), (1, 15),...,(36, 13), (36, 14), (26, 15). Run 2 (N11=16, NUMSTR=2) - (1, 16), (1, 17), (1, 18),..., (36, 16), (36, 17), (36, 18), etc.

See Figure 1 for an illustration of an ERTS image divided into 64 by 64 subimages. Note – the size of each subimage must not exceed 4096 points.

# ERTS IMAGE

# 4 Tapes for Each ERTS Image

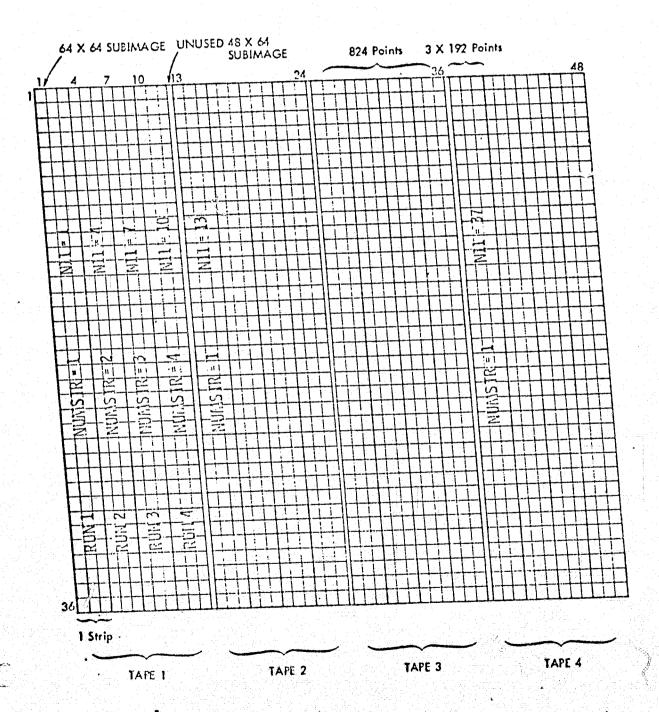


Figure 1.

SUBPROGRAM TITLE:

**ERTS** 

**VERSION:** 

II

DATE:

September, 1972

**UPDATE:** 

November, 1973

AUTHOR:

G. Gunnels

DOCUMENTED BY:

R. Bosley

PROGRAM LANGUAGE:

**GMAP** 

IMPLEMENTED ON:

HW635

**PURPOSE:** 

To read 7-track ERTS MSS data tapes.

ENTRY POINTS:

CALL EINIT (NOLS)

CALL ESKIP (NOSK)

CALL EREAD (I, LN)

CALL EREWND

ARGUMENTS:

NOLS

Number of words per scan line; returned by EINIT.

NOSK

The number of records to skip.

I

The array into which the NOLS words of data

from a line of ERTS data is placed.

LN

Returned by EREAD giving the line number of the

line of data returned. If LN =0, the end of file

was reached on the ERTS tape.

ERKOR LAGS:

MB

EREAD buffer is not large enough for a block of

ERTS data.

AI

EINIT was called twice.

NI

EINIT was not called before calling EREAD,

ESKIP, or EREWND.

UE

EOF encountered while reading 1D or

annotation blocks on ERTS tape.

EF

EOF encountered while trying to skip records

in ESKIP.

## COMMENTS:

EINIT initializes the ERTS tape so that data may be read, and must be called first. ESKIP skips over NOSK records (scan lines). EREWND rewinds the ERTS tape. EINIT must not be called twice. The data placed into array I by EREAD is in standard corresponding point forms. Since the ERTS MSS data has four channels, there are actually NOLS/4 points or cells per scan line.

# REQUIREMENTS:

ERTS tape must be on file code 'ES'.

#### ERTS TEXTURE ANALYSIS

SUBPROGRAM TITLE:

MAING

VERSION:

111

DATE:

October, 1971

**UPDATE:** 

June, 1973

AUTHOR:

R. M. Haralick

DOCUMENTED BY:

Robert J. Bosley

PROGRAM LANGUAGE:

FORTRAN IV

IMPLEMENTED ON:

HW 635

**PURPOSE:** 

To print out a picture of the subimage, copy it to file 2, and then process it through the texture subroutines FPLXIT to get the LEX arrays, IMOMTR to calculate the texture features, and RITOWT to output the results.

ENTRY POINT:

CALL MAING (IWORK, MERR, MERGE, PICTUR, IF)

ARGUMENTS:

**IWORK** 

NUMLIN by NUMPPL subimage array.

MERR

Set to 1 if an error occurs in fitting the LEX

arrays into IWORK.

MERGE

TRUE to merge the four LEX arrays into one.

**PICTUR** 

TRUE for a picture of the subimage.

IF

File code for the output tape.

#### COMMENTS:

The subimage sent in IWORK is scaled to fill a page for the picture printout, and at the same time it is copied to a scratch disc on file code '02'. If the size of the LEX arrays is greater than NUMPPL x NUMLIN, then an error message is printed and processing is terminated by MAINLN, after putting EOF marks on the output tape. Each subimage is quantized by

# CALLED BY:

MAINLN

SUBPROGRAMS REQUIRED:

KEQUAN

PITCHR

**FPLXIT** 

**IMOMTR** 

RITOWT

SUBPROGRAM TITLE:

KEQUAN

**VERSION:** 

11

DATE:

September, 1971

UPDATE:

June, 1973

AUTHOR:

G. Elliot

DOCUMENTED BY:

Robert J. Bosley

PROGRAM LANGUAGE:

FORTRAN IV

IMPLEMENTED ON:

HW635

PURPOSE:

To equal probability quantize the input array to NQ levels.

ENTRY POINT:

CALL KEQUAN (IA, NGL, NQ, IASIZE)

ARGUMENTS:

IA

Input array which is returned quantized.

NGL

Number of greytone levels in IA.

NQ

Number of quantizing levels.

IASIZE

Size of array IA.

ERROR FLAGS:

If the number of greytone levels exceeds 512, an error message is printed.

SUBPROGRAM TITLE:

PITCHR

**VERSION:** 

11

DATE:

July, 1969

UPDATE:

November, 1970

AUTHOR:

R. Cowles

DOCUMENTED BY:

G. Elliott

PROGRAM LANGUAGE:

GMAP

IMPLEMENTED ON:

HW635

PURPOSE:

To print out images in 13 grey levels.

ENTRY POINTS:

CALL PITCHR (IRRAY, ICELL, JCELL, INIT, IT, IMIN, IMAX,

NROW, NFIL, IFIL, NULW, NULD, AMAG, DMAG, \*)

CALL SNAP

CALL SNAPA (IARRAY)

CALL ENDBNR

ARGUMENTS:

**IRRAY** 

Array to be printed, either integer or floating

point.

ICELL

Number of rows in array. (row dimension)

**JCELL** 

Number of columns in array. (column dimension)

INIT

=0 if all of image to be printed out is in core

at time of call. Output will be done before

return to calling program.

=1 for reinitialization entry. Any of the arguments

previously specified with INIT = 0 with the

exception of INIT may now be changed. Return

will be made to the calling program without

any output. This is especially useful if the image

is read into core in pieces and the last piece

does not completely fill the array. >1 for initialization

entry. INIT will reflect the number of times entry is made at SNAP before final border is to be printed. Return is to the calling routine without any output.

INIT =0 is assumed.

=0 if array is floating point

11

and a

=1 if array is integer

II = 1 is assumed.

IMIN Minimum brightness level in array. Type of

IMIN should correspond to that indicated by II.

IMIN =0 is assumed.

IMAX Maximum brightness level in array. Type of IMAX

should correspond to that indicated by 11.

IMAX = 12 is assumed.

NROW Number of rows of array to be printed if full array

is not to be printed. This allows for partial printing.

NROW = ICELL is assumed.

NFIL Number of output files available if image is to

be output in strips that are NULW lines wide.

=0 for all output on file code 06

=1 for all output on file code IFIL

>1 for outputs in strips, on file codes specified

in array IFIL. NFIL=0 is assumed.

IFIL Array containing output file codes. Ignored unless

NFIL = 0. IFIL must be a variable rather than a

literal, since SNAP alters the value(s) of IFIL

to contain the location of the relevant file

control block in the upper half of the word.

NULW Number columns per output page. MAX = 129

NULW = 120 unless otherwise specified.

NULD Number of rows to be printed before a slew on the

top of the next page is given. NULD = ICELL\*DMAG+1.

AMAG Floating point magnification in width.

AMAG =1 is assumed.

DMAG Floating point magnification in length,

DMAG = 1 is assumed.

Error return if not enough output files are available. Return is made with NARG =-10.

If not specified, a message will be printed out on the accounting report and an NF report

will terminate execution.

### ERTS TEXTURE ANALYSIS

SUBPROGRAM TITLE:

**FPLXIT** 

**VERSION:** 

11

DATE:

September, 1971

UPDATE:

June, 1973

AUTHOR:

R. M. Haralick

DOCUMENTED BY:

R. J. Bosley

PROGRAM LANGUAGE:

FORTRAN IV

IMPLEMENTED ON:

HW 635

PURPOSE:

To compute the four nearest neighbor greytone matrices LEX1, LEX2, LEX3, LEX4, for angles of 90, 0, 135, and 45 degrees.

ENTRY POINT:

CALL FPLXIT (IDATA, LEX1, LEX2, LEX3, LEX4, NUMPPL, MERGE)

ARGUMENTS:

**IDATA** 

Scratch array holding two lines of the subimage.

LEX1 - LEX 4

Address indices for the four LEX arrays.

NUMPPL

Number of points in each line of the subimage.

MERGE

TRUE to merge the four LEX arrays into one array.

#### COMMENTS:

This subroutine reads two lines at a time from the subimage being processed, which is now on scratch disc file 02. After all the LEX arrays are created, they can be merged into one by setting MERGE to TRUE in MAINLN. The merge is performed by adding each array term by term and putting the total into LEX1.

SUBPROGRAMS REQUIRED:

INDEX

CALLED BY:

MAING

# ERTS TEXTURE ANALYSIS

SUBPROGRAM TITLE:

INDEX

VERSION:

1

DATE:

September, 1971

UPDATE:

September, 1971

AUTHOR:

R. M. Haralick

DOCUMENTED BY:

R. J. Bosley

PROGRAM LANGUAGE:

FORTRAN IV

IMPLEMENTED ON:

HW 635

PURPOSE:

To return to the calling program the single subscript for the LEX array that indicates where element (I, L) can be found, given its row and column subscripts I and L.

ENTRY POINT:

INDEX (I, J)

ARGUMENTS:

Row subscript for an element in the LEX array.

I J

Column subscript for an element in the LEX

array.

COMMENTS:

This subprogram is a FUNCTION.

CALLED BY:

**FPLXIT** 

**IMOMTR** 

### ERTS TEXTURE ANALYSIS

SUBPROGRAM TITLE:

**IMOMTR** 

VERSION:

11

DATE:

September, 1971

**UPDATE:** 

June, 1973

AUTHOR:

R. M. Haralick

DOCUMENTED BY:

R. J. Bosley

PROGRAM LANGUAGE:

FORTRAN IV

IMPLEMENTED ON:

HW 635

PURPOSE:

To calculate the moment texture statistics.

ENTRY POINT:

CALL IMOMTR (LEX1, LEX2, LEX3, LEX4, F, IQ, MERGE)

ARGUMENTS:

(

LEX1 - LEX4

Address indices for the four LEX arrays.

F

Cumulative distribution function.

IQ

Quantized output array of IEQPQ1,

MERGE

TRUE indicates the four LEX arrays have been

merged into one.

TEXTURE FEATURES:

1. Angular Second Moment

ANGMOM = 
$$\sum_{i=1}^{N_g} \sum_{j=1}^{N_g} P^2(i, j)$$

where N<sub>g</sub> is the number of grey tone levels, and P(i, j) is the array of joint probabilities.

3. Mean
$$AMEAN = \sum_{i=1}^{N_g} \sum_{j=1}^{N_g} i \cdot P(i, j)$$

4. Variance
$$SGMASQ = \sum_{i=1}^{N_g} \sum_{j=1}^{N_g} (i - AMEAN)^2 P(i, j)$$

5. Covariance
$$SGMAXY = \sum_{i=1}^{N_g} \sum_{j=1}^{N_g} (i - AMEAN) (j - AMEAN) P(i, j)$$

$$RATIO = \frac{SGMAXY}{SGMASQ}$$

7. Inverse Moment
$$N_g = \sum_{i=1}^g \sum_{j=1}^g \frac{P(i,j)}{1+(i-j)^2}$$

8. Average Contrast
$$N_{g-1}$$

$$DIFAVE = \sum_{k=1}^{N_{g-1}} k \cdot DIF(k)$$
where  $DIF(k) = \sum_{|i-j|=k} P(i, j)$ 

9. Variance of DIF
$$N_{g-1} = \sum_{k=1}^{N_{g-1}} k^2 \cdot DIF(k) - \left[\sum_{k=1}^{N_{g-1}} k \cdot DIF(k)\right]^2$$

10. Entrophy of DIF
$$N_{g-1}$$
DIFENT = - 
$$\sum_{k=1}^{N_{g-1}} DIF(k) \cdot log (DIF(k))$$

11. Average of Intensity
$$2N_{g}$$

$$SUMAVE = \sum_{k=2}^{g} k \cdot SUM(k)$$

where SUM = 
$$\sum_{i+j=k} P(i, j)$$

12. Variance of SUM 
$$2 N_g$$

$$SUMVAR = \sum_{k=2}^{2} k^2 \cdot SUM(k) - \begin{bmatrix} 2N_g \\ \sum_{k=2}^{g} k \cdot SUM(k) \end{bmatrix}^2$$

13. Entropy of SUM 
$$2N_g$$

SUMENT =  $-\sum_{k=2}^{g}$  SUM(k) · log (SUM(k))

14. True mean of probability function

TMEAN = 
$$\frac{1}{N_g} \sum_{i=1}^{N_g} F(i)$$

# COMMENTS:

The three remaining texture features are computed in subroutine COR: CORINF, CORMUT, and CORMAX. If MERGE is TRUE, then these features are computed for only the merged array, LEX1. Otherwise they are computed for each LEX array, corresponding to each of four angles.

# SUBPROGRAMS REQUIRED:

INDEX

IEQPQ1

COR

### CALLED BY:

MAING

### ERTS TEXTURE ANALYSIS

SUBPROGRAM TITLE:

COR

**VERSION:** 

П

DATE:

November, 1972

**UPDATE:** 

June, 1973

AUTHOR:

Sam Shanmugam

DOCUMENTED BY:

R. J. Bosley

PROGRAM LANGUAGE:

FORTRAN IV

IMPLEMENTED ON:

HW 635

**PURPOSE:** 

To calculate three measures of correlation between two discrete random variables X and Y whose joint probabilities of occurrence are known.

ENTRY POINT:

CALL COR(PXY, N, IOPT, Q, COR1, COR2, COR3)

INPUT ARGUMENTS:

PXY

Array of joint probabilities.

N

Size of the array PXY

IOPT

Option flag - if IOPT =0, then only CORI

and COR2 will be calculated; if IOPT =1,

then COR3 will also be calculated.

Q

Scratch array of size N x N. This array

is used only if IOPT is non-zero.

OUTPUT ARGUMENTS!

CORT

Maximal correlation measure.

COR2

Information measure of correlation.

COR3

Second type of maximal measure.

#### COMMENTS:

These three correlation measures are the last three texture features. For details of the measures see "Mutual Information and Maximal Correlation As Measure of Dependence," by C. B. Bell, in the Annals of Mathematical Statistics, vol. 43, 1962.

### CALCULATIONS:

1. 
$$COR1 = \frac{H(x, y) - H_1(x, y)}{max (H(x), H(y))}$$
  
where  $H(x, y) = \sum_{i} \sum_{j} log (P_{xy}^{2}(i, j))$   
 $H_1(x, y) = \sum_{i} \sum_{j} (log (P_{x}(i) P_{y}(j))) P_{xy}(i, j)$   
 $H(x) = \sum_{i} (log P_{x}(i)) P_{x}(i)$   
and  $H(y) = \sum_{j} (log P_{y}(j)) P_{y}(j)$   
2.  $COR2 = \sqrt{1 - e^{-2R}}$   
where  $R = H_2(x, y) - H(x, y)$ 

where 
$$R = H_2(x, y) - H(x, y)$$
  
 $H_2(x, y) = \sum_{i} \sum_{j} (\log P_x(i) P_y(j)) P_x(i) P_y(j)$ 

and 
$$P_{x}(i) = \sum_{i} P_{xy}(i, j), P_{y}(j) = \sum_{j} P_{xy}(i, j).$$

3. COR3 is computed using the eigenvector corresponding to the second largest eigenvalue of QQ<sup>T</sup>, where

$$Q(i, J) = \frac{P_{xy}(i, j)}{\sqrt{P_{x}(i) P_{y}(j)}}$$

CALLED BY:

**IMOMTR** 

### ERTS TEXTURE ANALYSIS

SUBPROGRAM TITLE:

**IEQPQ1** 

VERSION:

1

REPRODUCIBILITY OF THE ORIGINAL PAGE IS POOR

DATE:

September, 1971

UPDATE:

September, 1971

AUTHOR:

D. Goel

DOCUMENTED BY:

R. J. Bosley

PROGRAM LANGUAGE:

FORTRAN IV

IMPLEMENTED ON:

HW 635

PURPOSE:

To determine k levels of equal probability quantization for an array for which the cumulative distribution function is known for all elements.

ENTRY POINT:

CALL IEQPQ1 (N, K, F, IQ, IMIN)

ARGUMENTS:

N

Number of Items in array F to be equal

probability quantized.

K

Number of quantizing levels.

F

Input array to be quantized.

IQ

Output array of quantized levels.

MIM

The lowest possible level in the input data.

CALLED BY:

**IMOMTR** 

#### ERTS TEXTURE ANALYSIS

SUBPROGRAM TITLE:

**RITOWT** 

VERSION:

11

DATE:

September, 1971

UPDATE:

June, 1973

**AUTHOR:** 

R. M. Haralick

DOCUMENTED BY:

R. J. Bosley

PROGRAM LANGUAGE:

FORTRAN IV

IMPLEMENTED ON:

HW 635

PURPOSE:

To output onto printer, cards, or tape the texture features.

**ENTRY POINT:** 

CALL RITOWT (LEX1, LEX2, LEX3, LEX4, G, IQ, MERGE,

IF, PICTUR)

ARGUMENTS:

LEX1 -LEX4

Address indices for the LEX arrays.

G

CDF for the image data

IQ

Quantized output of IEQPQ1 of NQUANT

levels.

MERGE

TRUE Indicates that the four LEX arrays have

been merged into one array.

IF.

File code for output tape.

**PICTUR** 

TRUE indicates that a picture of the subimage

has been printed.

COMMENTS:

The output format for the listing is slightly different depending upon the PICTUR and merge options. The PNCH option determines whether cards or tope or neither are used to output the 17

texture features for each subimage. In any case, the texture features are listed on the printer. If PNCH = 1HY in the \$PARAM card in MAINLN, then cards are punch according to the following formats:

- for MERGE = TRUE: M1, N1, NFT, ANGMOM, ENTROP,
   RATIO, SGMASQ, SGMAXY, AMEAN, VIDMOM, KOUNT/
   TMEAN, DIFENT, DIFAVE, DIFVAR, SUMENT, SUMAVE,
   SUMVAR, KOUNT+1/CORINF, CORMUT, CORMAX, KOUNT+2.
   FORMAT (12, 1X, 212, 1X, 7F9.5, 19/8X, 7F9.5, 19/8X, 3F9.5, 36X, 19), where (M1, N1) is the subimage row, column coordinate.
- 2. for MERGE = FALSE: M1, N1, NFT/ANGMOM(4), ENTROP(4), KOUNT/RATIO(4), SGMASQ(4), KOUNT+1/SGMAXY(4), AMEAN(4), KOUNT+2/VIDMOM(4), TMEAN(4), KOUNT+3/DIFENT(4), DIFAVE(4), KOUNT+4/DIFVAR(4), SUMENT(4), KOUNT+5/SUMAVE(4), SUMVAR(4), KOUNT+6/CORINF(4), CORMUT(4), KOUNT+7/CORMAX(4), KOUNT+8, where (4) denotes four values, one for each angle.

FORMAT (/'THE SCENE(', 12, 1, ', 12, ') HAS BEEN REDUCED BY', 15/8(1X, 8F9.5, 17/)/1X, 4F9.4, 38X, 15).

If tape output on file code 'IF' is selected by PNCH = 1HT, then the texture features are written in binary as follows:

WRITE(IF) M1, N1, NFT, ANGMOM(K), ENTROP(K), RATIO(K),

SGMASQ(K), SGMAXY(K), AMEAN(K), VIDMOM(K),

TMEAN(K), DIFENT(K), DIFAVE(K), DIFVAR(K), SUMENT(K),

SUMAVE(K), SUMVAR(K), CORINF(K), CORMUT(K),

CORMAX(K), where K is one for MERGE = TRUE and is

4 for MERGE = FALSE denoting the number of values for each

measure.

If neither cards nor tape output is selected, then the LEX arrays are listed after the texture features.

CALLED BY:

( .

MAING

# 

SPECTR
GETIM / GETIT
ERTS
DIFFER
COVAR
MNCVIN / MNCV
CORREL

# CROSS-BAND TEXTURE ANALYSIS

PROGRAM TITLE:

**SPECTR** 

VERSION:

1

DATE:

January, 1974

UPDATE:

January, 1974

AUTHOR:

Robert J. Bosley

DOCUMENTED BY:

Robert J. Bosley

PROGRAM LANGUAGE:

**FORTY** 

IMPLEMENTED ON:

HW635

PURPOSE:

This program is the mainline of the spectral-textural analysis which obtain spectral-textural features for land-use classification

of ERTS MSS data.

ENTRY POINT:

CALL SPECTR (IMAGE, X, ILINE, IXDIM, IYDIM, NDIN)

INPUT ARGUMENTS:

**IMAGE** 

Array containing a subimage.

(IYDIM, IXDIM,

IDIN)

X (IYDIM,

Array containing the difference image.

IXDIM, IDIN)

ILINE

Array one ERTS line is read into.

IXDIM

Column dimension of IMAGE, X.

IYDIM

Row dimension of IMAGE, X.

NDIN

Number of components, bands, in IMAGE, X.

INPUT PARAMETERS: under NAMELIST 'PARAM':

NDIM

Number of components desired in IMAGE:

Assumed to be NDIN.

NUMLIN

Number of lines in subimage; Assumed to be IYDIM.

NUMPPL Number of columns in subimage; Assumed to

be IYDIM.

FMT Format used to output elements of covariance

matrix; assumed to be 'Ell.4'.

TITLE 80 column title for run.

OPT TRUE to print covariance matrix; assumed FALSE.

1DIST Distance between neighboring cells for difference

array; assumed to be 1.

IRSTRT Starting row in ERTS image; assumed to be 1.

IRSTOP Stopping row in ERTS image; assumed as last row.

LAPHOR Number of horizontal points that subimages over-

lap; assumed to be 0.

LAPVER Number of vertical points that subimages overlap;

assumed to be 0.

PNCH TRUE for output on cards, FALSE for output to

file code 01 for tape or disc.

# EXAMPLE OF DRIVER:

DIMENSION IMAGE (16, 17, 8), X (16, 17, 8), ILINE (3300) EQUIVALENCE (IMAGE, X, ILINE(130))

IXDIM =17

IYDIM =16

NDIN =8

CALL SPECTR (IMAGE, X, ILINE, IXDIM, IYDIM, NDIN)

STOP

END

This driver will set up the spectral-textural analysis mainline SPECTR to process 16 x 16 subimages over 8 components with IDIST =1. Note IXDIM must include NUMPPL plus IDIST points, and array ILINE must have at least NUMPPL × NDIM points outside of any other array. These points form array XLINE in COVAR.

#### REQUIREMENTS:

- 1. Core 25k for IMAGE (32, 33, 8)
- 2. ERTS input tape must be on file code 'ES'
- 3. Random access disc file on file 11, eg. \$ FILE II AIIR, OR.
- 4. Subprograms required:

DRIVER

SPECTR

**GETIM** 

SETDIM (Fortran callable program to initialize HEMP package)

**GETIT** 

**ERTS** 

DIFFER

COVAR

MNCVIN

MNCV

CORREL

SFA07F

HEMDET (Fortran callable program from HEMP library to solve for determinant of matrix).

#### COMMENTS:

These analysis programs obtain a series of NUMLIM by NUMPPL by NDIM subimages from the ERTS input tape and outputs a feature vector with (1 + NDIM (NDIM-1)/2) components for each subimage.

The input data is processed in horizontal rows of subimages that may overlap both horizontally and vertically. The distance between neighboring resolution cells used to get the difference array is variable. Note that IXDIM must include NUMPPL plus IDIST points, and that the array ILINE must have at least NUMPPL × NDIM points outside of any other array because these are used for array XLINE in COVAR.

Other than this, arrays IMAGE, X, and ILINE may be equivalenced

to conserve core, as in the example for a DRIVER. The first feature component on the output file is the entropy measure, and the remaining NDIM (NDIM-1)/2 components are elements of the correlation matrix. See the GETIM subprogram for alisting of all 8 possible components for a subimage.

CALLED BY:

**DRIVER** 

# CROSS-BAND TEXTURE ANALYSIS

SUBPROGRAM TITLE:

**GETIM** 

VERSION:

J.

DATE:

January, 1974

UPDATE:

January, 1974

AUTHOR:

Robert J. Bosley

DOCUMENTED BY:

Robert J. Bosley

PROGRAM LANGUAGE:

**FORTY** 

IMPLEMENTED ON:

HW635

PURPOSE:

To get a row of subimages from the ERTS input tape and copy them

onto a random access disc file.

ENTRY POINTS:

CALL GETIM (ILINE, IDIST, NDIM, IRSTRT, IRSTOP, NUMLIN,

NUMPPL, LAPVER, LAPHOR, NHOR, INCR, IPEND)

CALL GETIT

INPUT ARGUMENTS:

ILINE

Array into which one ERTS line is read.

IDIST

Distance between neighboring resolution cells

whose differences form the difference array, X.

NDIM

Number of components in each resolution cell.

IRSTRT

Starting line of ERTS data.

IRSTOP

Stopping line of ERTS data.

NUMLIN

Number of lines in each subimage.

NUMPPL

Number of points per line (columns) in each subimage.

LAPVER

Number of lines that subimages overlap.

LAPHOR

Number of columns that subimages overlap.

### **OUTPUT ARGUMENTS:**

NHOR

Number of horizontal overlapping subimages in image.

INCR

Horizontal increment to the first column of the

next subimage in the row.

**IPEND** 

Last cell in the row.

#### REQUIREMENTS:

Random access disc file on file code II: and FILE II, AIIR, IOR.

### COMMENTS:

This program is initialized by calling GETIM which initializes the ERTS input tape and sets up the disc on file II for random access with fixed length records of NDIM words, up to a maximum of NDIM =8. The eight possible greytone components are:

- 1./ Band 2
- 2. Band 3
- 3. Band 4
- 4. Band 2 x Band 2
- 5. Band 3 x Band 3
- 6. Band  $4 \times B$  and 4
- 7. Band  $2 \times B$  and 3
- 8. Band 2 x Band 4, where band 1 through 4 is MSS band 4 through 7. It is suggested that all eight components be used and the best of these be selected for feature vector components. This gives a total of 29 components, including the entropy measure.

After calling GETIM, all further calls are made to GETIT which goes down the input data file line by line copying to the random access disc an entire row of NHOR subimages of NDIM components. Note that MSS band 4 (band 1 here) has been deleted because of its high correlation with MSS band 5 (band 2 here).

### CALLED BY:

(

SPECTR

SUBPROGRAM TITLE:

**ERTS** 

**VERSION:** 

II

DATE:

September, 1972

**UPDATE:** 

November, 1973

AUTHOR:

G. Funnels

DOCUMENTED BY:

R. Bosley

PROGRAM LANGUAGE:

GMAP

IMPLEMENTED ON:

HW635

**PURPOSE:** 

To read 7-track ERTS MSS data tapes.

ENTRY POINTS:

CALL EINIT (NOLS)

CALL ESKIP (NOSK)

CALL EREAD (I, LN)

CALL EREWND

ARGUMENTS:

NOLS

Number of words per scan line; returned by EINIT.

NOSK

The number of records to skip.

1

The array into which the NOLS words of data

from a line of ERTS data is placed.

LN

Returned by EREAD giving the line number of the

line of data returned. If LN =0, the end of file

was reached on the ERTS tape.

ERROR FLAGS:

MB

EREAD buffer is not large enough for a block of

ERTS data.

A1

EINIT was called twice.

NI

EINIT was not called before calling EREAD,

O

ESKIP, or EREWND.

UE

EOF encountered while reading ID or

annotation blocks on ERTS tape.

EF

EOF encountered while trying to skip records

in ESKIP.

#### COMMENTS:

EINIT initializes the ERTS tape so that data may be read, and must be called first. ESKIP skips over NOSK records (scan lines). EREWND rewinds the ERTS tape. EINIT must not be called twice. The data placed into array I by EREAD is in standard corresponding point forms. Since the ERTS MSS data has four channels, there are actually NDLS/4 points or cells per scan line.

### REQUIREMENTS:

ERTS tape must be on file code 'ES'.

# CROSS-BAND TEXTURE ANALYSIS

SUBTROGRAM TITLE:

DIFFER

VERSION:

1

DATE:

January, 1974

UPDATE:

January, 1974

AUTHOR:

Robert J. Bosley

DOCUMENTED BY:

Robert J. Bosley

PROGRAM LANGUAGE:

**FORTY** 

IMPLEMENTED ON:

HW635

PURPOSE:

To calculate the nearest neighbor difference array.

ENTRY POINT:

CALL DIFFER (IA, X, IXDIM, IYDIM, NDIM, IDIST, NUMPPL,

NUMLIN)

INPUT ARGUMENTS:

IA(IYDIM,

Array containing the subimage being processed.

IXDIM, NDIM)

IXDIM

Column dimension of IA and X.

IYDIM

Row dimension of IA and X.

MIDN

Number of components of each resolution cell.

NUMPPL

Number of columns in the subimage.

NUMLIN

Number of lines in the subimage.

**OUTPUT ARGUMENTS:** 

X(IYDIM,

Array of nearest neighbor differences.

IXDIM, NDIM)

COMMENTS:

This subroutine will replace the original subimage in array IA with the nearest neighbor horizontal difference: (II - J1, I2 - J2,...,IN - JN) where I and J are N-dimensional horizontally neighboring resolution cells separated by distance IDIST. Arrays IA and X may be equivalenced to occupy the same area of core. Note that the absolute value is used to get the differences. This gives only the positive half of the distribution of differences I-J and J-I. This shifts the mean of the distribution from the origin and must be accounted for in COVAR when the covariance matrix of the difference array is calculated.

CALLED BY:

**SPECTR** 

### CROSS-BAND TEXTURE ANALYSIS

SUBPROGRAM TITLE:

COVAR

VERSION:

DATE:

January, 1974

UPDATE:

January, 1974

AUTHOR:

Robert J. Bosley

Robert J. Bosley

DOCUMENTED BY:

**FORTY** 

PROGRAM LANGUAGE: IMPLEMENTED ON:

HW635

**PURPOSE:** 

To calculate the covariance matrix of the difference array.

ENTRY POINT:

CALL COVAR (XLINE, NDIM, NUMPPL, X, IXDIM, IYDIM,

NUMLIN, NDIN, COV)

INPUT ARGUMENTS:

XLINE(NDIM,

Array used to send one line of the difference

NUMPPL)

array to MNCVIN.

NDIM

Number of components of each vector in X.

NUMPPL

Number of columns of vectors in X.

X

Nearest neighbor difference array.

IXDIM, IYDIM Column, row dimensions of array X.

NUMLIN

Number of rows of vectors in X.

NDIN

Dimension of COV array.

OUTPUT ARGUMENTS:

COV (NDIN,

Covariance matrix of the difference array X.

NDIN)

REQUIREMENTS:

Subroutine MNCVIN.

COMMENTS:

Array XLINE is formed from the first NDIM x NUMPPL points of array ILINE in SPECTR. Hence at least the first NDIM x NUMPPL words of ILINE must not be equivalenced into array X.

Since only the positive differences were used to make array X by DIFFER, the mean is reset to zero for each component.

CALLED BY:

**SPECTR** 

### CROSS-BAND TEXTURE ANALYSIS

SUBPROGRAM TITLE:

MNCVIN

VERSION:

DATE:

August, 1973

**UPDATE:** 

August, 1973

AUTHOR:

James D. Young

DOCUMENTED BY:

James D. Young

PROGRAM LANGUAGE:

FORTRAN IV or FORTY

IMPLEMENTED ON:

HW635

PURPOSE:

To calculate the mean vector and covariance matrix for each category of a set of vectors, based on a specified percentage of the vectors randomly chosen within the set.

ENTRY POINTS:"

CALL MNCVIN (NVPCAL, NDIM, NCALL, PERCNT, NCAT, X, NTRUTH, COV, XMEAN, SCTMEN, SAMSZ, IERROR, JERROR)

CALL MNCV

INPUT ARGUMENTS:

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NVPCAL

Number of vectors per call.

NDIM

Dimension of data vectors.

**NCALL** 

Number of calls.

PERCNIT

Percentage of total number of vectors from which

the mean and covariance matrices will be

calculated.

NCAT

Number of categories considered; set to 1 if

only one set of statistics will be calculated for all data, set to the number of categories in data set if one set of statistics will be calculated for

each category.

X (NDIM,

Matrix containing input data vectors in its

NVPCAL)

columns.

NTRUTH

Vector containing the ground truth integers, 1

(NYPCAL)

through NCAT, associated with the data vectors

of X; if NCAT is 1 this vector is ignored.

#### **OUTPUT ARGUMENTS:**

COV (NDIM, Matrix containing covariance matrices of the data.

NDIM, NCAT)

XMEAN (NDIM, Matrix containing mean vectors of the data. NCAT)

SCTMEN(NDIM, Scratch matrix.

NCAT)

SAMSZ (NCAT) Vector with the number of vectors used to calculate the statistics for each category.

**IERROR** 

Error flag when returned non-zero:

- 1. If NVPCAL .LE. 0
- 2. if NDIM .LE. 0
- 3. If NCAL .LE. 0
- 4. if PERCNT .GT. 100. or so small that less than 2 vectors will be used to calculate all the statistics.
- 5. If NCAT .LE. 0

**JERROR** 

Error flag when returned non-zero:

1. If an illegal ground truth label is formed.

#### COMMENTS:

One call to MNCVIN Initializes this routine. Calls to MNCV should be performed NCALL times, each with the next line of vectors in X. After MNCV has been called NCALL times, the mean vector and covariance matrix for each category is completed. For use in the Spectral-Textural Analysis programs, PERCNT is set to 100 and NCAT is set to 1.

# CROSS-BAND TEXTURE ANALYSIS

SUBPROGRAM TITLE:

CORREL

**VERSION:** 

I

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DATE:

January, 1974

UPDATE:

January, 1974

AUTHOR:

Robert J. Bosley

DOCUMENTED BY:

Robert J. Bosley.

PROGRAM LANGUAGE:

**FORTY** 

IMPLEMENTED ON:

HW 635

PURPOSE:

To calculate the correlation matrix given the covariance matrix

of the difference array.

ENTRY POINT:

CALL CORREL (COV, NDIM, COR)

INPUT ARGUMENTS:

COV

Covariance matrix of the difference array

NDIM

Order of matrix COV.

OUTPUT ARGUMENTS:

COR

Correlation matrix of COV.

CALLED BY:

SPECTR

RCLASS
XIN
LINEAR
WEIGHT

### LINEAR DISCRIMINANT CLASSIFIER

SUBPROGRAM TITLE:

**RCLASS** 

VERSION:

1

DATE:

September, 1972

UPDATE:

November, 1972

AUTHOR:

Sam Shanmugam

DOCUMENTED 3Y:

Sam Shanmugam

PROGRAM LANGUAGE:

FORTRAN IV

IMPLEMENTED ON:

HW 635

PURPOSE:

This subroutine is the mainline for routines which implement a decision rule using piecewise linear discriminant functions. It calls subroutine XIN to read in the pattern vectors, and calls LINEAR to get the decision rule and classify the pattern vectors.

ENTRY POINT:

CALL RCLASS (WORK, ISIZE)

**ARGUMENTS:** 

WORK

Scratch array of size ISIZE which holds

the training vectors and the weight vectors.

ISIZE

Dimension of array WORK.

INPUT PARAMETERS:

Card 1. Format (411)

NOPT1

Set to 1 to print out training patterns;

otherwise set to zero.

NOPT2

Set to 1 to print out test patterns; otherwise

set to zero.

NOPT3

Set to 0 to list only the contingency table

for the training patterns; otherwise set to 1 and the classification of each training pattern is listed as well as the contingency table.

NOPT4 Set to 0 for only the contingency table of the test set; otherwise set to 1 for the classification of each test pattern as well.

Card 2. Format (515)

NTOT The total number of pattern vectors in the

data set.

NPART out of every ten pattern vectors in the

data set will be used for training. The remaining

will be used as test patterns.

NDIM The number of measurements per vector plus two.

NC The number of ground truth categorles.

NPAIR Twice the maximum number of training patterns

in any one category.

### REQUIREMENTS:

1. Maximum number of categories is 15.

2. Maximum number of components, NDIM, is 100.

3. Pattern vectors must be sorted by category.

4. A scratch disc file must be on 02.

5. ISIZE must be at least

NDIM (NTRAIN + 10) + 1000 + (NC (NC + 1)/2)ND + NPAIR • ND where ND = NDIM -1

and NTRAIN = number of training patterns.

6. Pattern vectors must be written in binary to disc file 01 as follows:

WRITE (01) 1GT, MI, NI, NFT, (FEAT(I), I=I, NMEAS) where

IGT is the ground truth category.

M1, N1, NFT are not used - may be used as

1D tags

FEAT is the feature vector

NMEAS is the number of measurements per feature vector.

#### 7. Subprograms required

DRIVER

**RCLASS** 

XIN

LINEAR

WEIGHT

#### ERROR FLAGS:

If ISIZE is too small, processing is terminated and an error message is listed.

#### THEORY:

Using a regression type algorithm the program obtains a set of hyperplanes for separating the training patterns of different category pairs. A total of NC(NC-1)/2 hyperplanes are determined. Test patterns are identified by taking a majority vote on this set of hyperplanes. For complete details, see "Introduction to Statistical Pattern Recognition" by Y. Fukunaga, Academic Press, 1972.

#### COMMENTS:

The input data file on 01 should have a total of NTOT logical records in binary. Each logical record must be of length NDIM + 2 words, where word 1 is the ground truth category and words set is sorted into training and test sets according to NPART. Training vectors are stored in WORK and test vectors are copied to disc 02.

#### CALLED BY:

DRIVER

EXAMPLE OF DRIVER:

DIMENSION WORK (10000)

ISIZE = 10000

CALL RCLASS (WORK, ISIZE)

STOP

END

## LINEAR DISCRIMINANT CLASSIFIER

SUBPROGRAM TITLE:

XIN

VERSION:

11

DATE:

September, 1972

UPDATE:

December, 1973

AUTHOR:

Sam Shanmugam

DOCUMENTED BY:

Robert J. Bosley

PROGRAM LANGUAGE:

FORTRAN IV

IMPLEMENTED ON:

HW 635

PURPOSE:

To read the parameter cards and the Input data set, copying the test vectors to disc.

ENTRY POINT:

CALL XIN (WORK, U)

ARGUMENTS:

WORK

Array training vectors are read into

11

Scratch array

CALLED BY:

**RCLASS** 

COMMENTS:

This version does not use subroutine POST to position the input file 01. Hence the input data file must be the first file on 01.

#### LINEAR DISCRIMINANT CLASSIFIER

SUBPROGRAM TITLE:

LINEAR

VERSION:

1

DATE:

September, 1972

UPDATE:

November, 1972

AUTHOR:

Sam Shanmugam

DOCUMENTED BY:

Sam Shanmugam

PROGRAM LANGUAGE:

FORTRAN IV

IMPLEMENTED ON:

HW 635

PURPOSE:

Using the set of training patterns, this program obtains a set of hyperplanes for pairwise separation of training patterns of different categories. The program also identifies the test patterns on a majority vote on the hyperplanes and outputs contingency table.

**ENTRY POINT:** 

CALL LINEAR (XTRAIN, XTEST, W, U, DUMMY)

ARGUMENTS:

XTRAIN

Matrix containing training patterns.

XTEST

Matrix containing test patterns.

W

Array of weight vectors.

U

Matrix used for calculating the boundary

between category pairs.

DUMMY

Scratch array.

CALLED BY:

**RCLASS** 

SUBPROGRAMS REQUIRED:

WEIGHT

#### LINEAR DISCRIMINANT CLASSIFIER

SUBPROGRAM TITLE:

WEIGHT

VERSION:

I

DATE:

September, 1972

**UPDATE:** 

November, 1972

AUTHOR:

Sam Shanmugam

DOCUMENTED BY:

Sam Shanmugam

PROGRAM LANGUAGE:

FORTRAN IV

IMPLEMENTED ON:

HW 635

**PURPOSE:** 

To find the minimum mean square fit hyperplane for separating the training patterns of two different categories.

**ENTRY POINT:** 

CALL WEIGHT (U, DUMMY, WT, ND, NIJ)

INPUT ARGUMENTS:

U

Array containing the patterns of category

I and category J.

DUMMY

Scratch array.

ND

ND+1 is the dimension of the pattern vector.

NIJ

Number of vectors in U.

**OUTPUT ARGUMENTS:** 

WT

Weight vector which defines the hyperplane

separating categories I and J.

CALLED BY:

LINEAR

SUBPROGRAMS REQUIRED:

MINV

Matrix inversion program from the IBM

Scientific Subroutine Package.

# IV.2-a ERTS Retrieval Program Listings

RETV

ERTS

PIXEY

ZEQUAN

PITCHR

WRTDSK

RDDSK1

KEQUAN

RDDSK2

12-12-74 18-974 ERT

ERTS RETRIEVAL PROGRAM

	ETV ERTS RETRIEVAL PROGRAM	RETVOODL
_	ETV ERTS RETRIEVAL PROGRAM	SETVOODS
C	VEGETON . MOSTTEN BY BURGSLEY JAN 1974	RETV0003
C	VERSTON 1 WRITTEN BY RJ BOSLEY JAN 1974	RETV0004
C	rangan dan kacamatan dan k	RETV0005
C		RETVOOD6
C	THE TO THE MA NEEDE FOR THE FOREST CALCAND CANONICAL CONTRACTOR CONTRACTOR	RETVOOR7
C	DEPOTEUR ONTO EDIM STANIARI NASA EKIS UATA TALIAS AMS SELIS III.	RETVOORS
Č	THACE DATA THE A PROTUPEL OR CREYTONE LIST NO. OR COPY II UNIO AN	7 7
C	OUTDUT TARE ON ETIE PODE *TELL COORDINATES MAY BE TIMER IN	RETVOU09
Č	MILITHETERS OR IN ROW. INLUMN COUNTY FOR REASONABLE BEFALLINGT	RETVO010
Č	BATA TO DEAD THE GICKS OF 41 LINES BY 41 POINTS. UNE EXISTANCE	RETVO011
Q	A L. TUEN OF COVERED BY 21 HORTZONTAL BLOCKS. LEAVING 4 PULNIS	RETVO012
	LEFT AT THE END OF EACH LINE. NOTESOMETIMES ON THE FIRST TAPE	RETVO013
Ç	OF AN IMAGE, THE FIRST FOUR POINTS ARE 255 AND WILL ADVERSELY	RETV0014
C	AFFECT A PICTURE PRINTOUT. IF SO, SKIP THE FIRST FOUR POINTS BY	RETV0015
Ç	ATTACKS TAGTOT OF	RETVO016
Ç	SEITING ICSTRI=5. NOTEIF THE POINT ICSTRI IS NOT A MULTIPLE OF 41 FROM THE	9ETV0017
C	NOTEIF THE PUINT LUSIK! IS NOT A HOUSE NECESSARI Y SE	RETV0018
C		
C	OUTPUTTED SINCE THE BLOCKS ARE DETERMINED BY THE ICSTRY POSITION.	PETVO020
C	THEREFORE IT IS SUGGESTED THAT IF THE DATA OUT TO THE END OF EACH	2FTV0021
C	LINE IS DESIRED. THAT THE COORDINATES BE SPECIFIED IN ROW, COLUMN	DETVO022
C	FORMAT AND THAT THEY BE PREDETERMINED SO AS TO DOTPOT THE DESTREE	RETVO023
Ö	DOTATO THE FOTS TIME.	RETV0024
C	A SPECIAL PICTURE RUN TO PRINT OUT AND REDUCE ANY IMAGE OVER	RETVO025
C	THE ENTIRE TARE CAN BE MADE BY SETTING SPIC TO .TRUE. IN SPAKAN	
Č	AND THEN SPECIFYING PICTURE PARAMETERS UNDER NAMELIAL APICIAN.	RETV0026
Č	SEE THE PIXEY PROGRAM FOR AN EXAMPLE OF A SAMPLE RUN.	RETV0027
Ç		RETV0028
: Ç	INPUT PARAMETERS UNDER NAMELIST /PARAM/	RETV0029
	NBAND BAND NUMBER TO BE SELECTED	RETV0030
Č	SET=5 FOR ALL BANDS	RETVO031
C	IRSTRT, ICSTRT ROW, COLUMN STARTING COORDINATES	RETV0032
C	TRETOR TOSTOR ROW-COLUMN STOPING COORDINATES	RETV0033
0	NUMBER OF HORIZONTAL MAY MAI BLOCKS	RETV0834
Ċ	NHOR THAT COVERS AREA SELECTED	RETV0035
C	ANALOGO OF LICENTAGE OF OCCUPANTION	RETV0036
C	NVERT NUMBER OF VERILORS SOVERING	RETV0037
C	The state of the s	RETV0038
C	THE PART OF THE PA	RETV0039
C	The second secon	RETV0040
C	TO THE TO DEAD INTO	RETV0041
C	THE STATE OF THE S	
C	TOTAL STATE OF THE PROPERTY OF	RETVO043
C	PIC TRUE FOR PICTURE OUTPUT	RETVO044
C	SPIC TRUE FOR SPECIAL PICTURE RJN	RETV0045
C	QUAN TRUE FOR QUANTIZED PLUTURE OUTPUT	RETV0045
Č	PONT TRUE FOR GREY-TONE LISTING	RETV0047
Č	TAPE TRUE FOR TAPE OUTPUT	The same of the sa
0000	MILLI TRUE IF COORD ARE SPECIFIED IN MM.	25 I VU140
Ö	こうしょうこうじょうしゅん 森林女子 こうしゅうしゅうじゅう 不り付置される 外外をおは自身保持ではは得りを放送する あっちりが失る こう	RETVOOS
Č		7461A0050

```
TO BE FALSE--FROM A 7 X 7 INCH PRINTRETVO051
                                                                             RETV0052
C
                                                                             RETV0053
C
                                                                             RETVO054
      RESTRICTIONS.
C
         1. ERTS INPUT TAPE MUST PE ON FILE CODE "ES".
                                                                              RETVO055
C
         2. FOUR DISC FLES MUST BE ON FILES 11, 12, 13, 14.
C
         3. ANY OUTPUT TAPE MUST OF POSITIONED ON FILE CODE "IFIL".
                                                                              RETVO056
              ALL COORDINATES MUST BE DETERMINED RELATIVE TO THE INPUT
                                                                              RETVO057
C
               TAPE---THAT IS, ISSTOP MUST NOT EXCEED 824 COLUMNS OR
                                                                              RETV0058
               46MM. STARTING COORDINATES MUST BE AT LEAST 1.
                                                                              RETV0059
C
                                                                              RETVOOSO
C
                                                                              RETV0061
      SUBPROGRAMS REQUIRED.
                                                                              RETV0052
00000000
                                                                              RETV0063
               RETV
                  ERTS (WITH EREWND)
                                                                              RETV0064
                  PIXEY
                                                                              RETV0065
                      ZEQUAN
                                                                              RETV0066
                      ERTS
                                                                              RETV0067
                      PITCHR
                                                                              RETV0058
                   WRTOSK
                                                                              RETV0069
                   RDDSK1
C
                                                                              RETV0070
                      KEQUAN
                                                                              RETV0071
                      PITCHS
CCC
                                                                              RETV0072
                   RDDSK2
                                                                              RETV0073
                                                                              RETV0074
                                                                              RETV0075
       DIMENSION IMAGE(41.82), ILINE(3300), TITLE(14)
                                                                              RETV0076
       EQUIVALENCE (IMAGE(1,1), LINE(1))
                                                                              RETVOO77
       LOGICAL EOF, PIC, SPIC, QUAN, PRNT, TAPE, SMALL, MILLI
                                                                              RETV0075
                           ./
       DATA BLANK/
       NAMELIST /PARAM/NBAND, PTC, QUAN, PRNT, TAPE, IRSTRT, ICSTRT, IRSTOP,
                                                                              RETV0079
                                                                               RETVOORD
                           ICSTOP, IFIL, TITLE, MILLI, SPIC
                                                                               RETV0081
                                                                               RETV0082
 C
       ***** SECTION I --- SET UP PARAMETERS FOR PROCESSING ****
                                                                               RETVOOSE
 C
                                                                               RETV0084
 C
                                                                               RETV0085
                                      INITIALIZE ERTS AND EOF FLAG
                                                                               RETV0086
 C
       CALL EINIT (LENGTH)
                                                                               RETV0087
        CALL FLGEOF (05,EOF)
                                                                               RETVOOSE
                                      INITIALIZE PARAMETERS
                                                                               RETVOOSS
       PIC=.TRUE.
 1001
        SPIC=.FALSF.
                                                                               RETV0091
        QUAN=.TRUE.
                                                                               RETV0092
        PRNT= . FALSE .
                                                                               RETV0093
                                                                               RETVOUS
        TAPE= . FALSE .
                                                                               RETV0095
        SMALL = . FALSE .
        MILLI= FALSE .
                                                                               RETV0096
        DO 7 I=1.14
                                                                               RETV0097
                                  REPRODUCIBILITY OF THE
        TITLE(I) = PLANK
                                                                               RETVOO9
  7
                                  ORIGINAL PAGE IS POOR
                                                                               RETVOUSE
        IFIL=2
        NB AND=2
                                                                                RETV010
        IRSTRT=1
```

# REPRODUCIBILITY OF THE ORIGINAL PAGE IS POOR

02-12-74 18.974 ERTS RETRIEVAL PROGRAM

	ICSTRT=1			RETV0101
	IPSTOP=0			RETV0102
	. =			RETV0103
_	ICSTOP=0	•	READ IN PARAMETERS	RETV0104
С	0040400	40443	KEAU IN PARAMETERS	RETVOID5
	READ (05,P	АЧАПІ	CHECK FOR END OF CARDS	RETV0106
C	75 (505)	STOR	CHECK FOR END OF CAROS	RETV0107
_	IF (EOF)	STOP	WRITE OUT THE PARAMETERS	RETV0108
C		\		RETV0109
		) (TITLE(I),I=1,1	41 AUSTUR	RETV0110
		EQ.5) WRITE(6,2)		RETV0111
	<del>-</del>	WRITE(6,3) IFIL		RETV0112
		WRITE(6.4) QUAN	PERDE TOCTOR	RETVO113
		) IRSTRT-IRSTOP,I		RETVO114
1		X, ERTS RETRIEVAL		RETV0114
		BAND NUMBER IS .		RETVO116
2			S WILL BE PROCESSED!	
3			L BE CREATED ON FILE (13)	RETV0117
4		PICTURE QUANTIZATI		RETVOILS
5		STARTING ROW IS		RETV0117
	•	STARTING COLUMN IS	*,16,10X,*END_NG COLUMN IS *,16)	RETV0120
C			CHANGE MM COORD INTO ROW AND COL	RETV0121
		LLI) GO TO 19		RETV0122
	WRITE (6,6		Christian Christian	RETV0123
6	FORMAT (	COORDINATES ARE IN		RETV0124
C		66 -6 46	GET THE CORRECT IMAGE SIZE	RETV0126
	IF (SMALL)	GO TO 10	ACCOUNT THAT A COTHE USC 402MM VERT	RETV0127
Ç			ASSUME THAT A PRINT HAS 183MM VERT	RETV0128
Ç			AND 184 MM ACROSS OR 2336 ROWS VERT AND 3296 POINTS ACROSS.	RETV0129
C			HOWEVERSINCE THE TAPE ONLY COVERS	RETVOLSO
C			ONE FOURTH ACROSS AN IMAGE, THEN USE	RETV0131
C			46MM ACROSS AND 824 COLUMNS ACROSS.	RETV0132
U	TOCTOT-TO	STRT#2336/180-12	40111 ACKOSS AND 024 COCOMIS HOROSSE	RETV0133
		STOP*2336/180		RETV0134
		STRT*824/46-17	이 문화 시간에 되는 것이 하는데 그는 것 같아요? 그렇게 되었다.	RETV0135
		STOP*824/46		RETV0136
	GO TO 15	11 UF 1024/40		RETV0137
	90 10 15		DO SMALL NEGATIVE COORDINATES	RETV0138
C			A NEGATIVE IS 70MM BY 70MM	RETV0139
10	TOCTOT-TO	STRT*2336/70-31	W MEANITAE 12 LAURE DA LAURA	RETV0140
10		STOP*2336/70		RETV0141
		STRT*824*2/35-46		RETV0142
		STOP*824*2/35		RETV0143
С	103107-10		WRITE OUT THE NEW COORDINATES	RETV0144
15	UDITE/6.1	6) IRSTRI-IRSTOP.		RETV0145
16			POW AND COLUMN FORMAT ARE/	RETV0146
10	1	STADITUG POU		RETV0147
		STARTING CO. I	IS .16.10X, ENDING COLUNN IS .16)	
С			CHECK COORDINATES SO THEY FALL IN	RETV0149
Č			ONE TAPE	RETV0150
~			는 사람 전투 현실 <sup>및</sup> 문화 문화 문화를 받았습니다. 그 그 그는 생각으로 된다고 싶으고 있다고 있다.	

```
RETV0151
                         GO TO 20
      IF (ICSTOP.GT.824)
                                                                           RETV0152
19
                                   CHECK PARAMETERS
                                                                           RETV0153
                      GO TO 20
                                                                           RETV0154
      IF (NBAND. GT.5)
                      GO TO 20
                                                                           RETV0155
      IF (NBAND.LT.1)
      IF (IRSTRT-LT-1) GO TO 20
                                                                           RETV0156
                       GO TO 20
                                                                           RETV0157
      IF (ICSTRT-LT-1)
      IF (IRSTOP.LT.IRSTRT) GO TO 20
                                                                           RETV0158
      IF (ICSTOP.GT.ICSTRT) GO TO 22
                                                                           RETV0159
      FORMAT(///* ***EXECUTION TERMINATED FOR THIS RUN--ERROR IN PAPAMETRETV0160
20
21
                                                                            RETV0162
     1ERS'/1H1)
                                                                            RETVU163
      GO TO 1001
                                   CHECK FOR SPECIAL PICTURE RUN
                                                                            RETV0164
      IF (.NOT.SPIC) 50 TO 18
      CALL PIXEY (ILINE, ILINE, IRSTRT, IRSTOP, ICSTRT, ICSTOP, QUAN, NBAND)
                                                                            RETV0165
22
                                                                            RETV0166
                                                                            RETV0157
      GO TO 1001
                                    POSITION THE INPUT TAPE
                                                                            RETV0168
C
      NOSK=IRSTPT-1
                                                                            RETV0169
18
                                                                            RETV0170
       CALL EREWND
       IF (NOSK.NE.0) CALL ESKIP(NOSK)
                                                                            RETV0171
       WRITE(6,23) LENGTH
                                                                            RETV0172
       FORMAT( * LENGTH OF ONE ERTS LINE IS . 16)
                                                                            RETV0173
 23
       IF (LENGTH.LE.3300) GO TO 25
                                                                            RETV0174
       FORMAT(/// LENGTH OF LINE ON ERTS EXCEEDS DIMENSION OF ARRAY ILINRETVO175
      1E---EXECUTION TERMINATED*)
                                                                            RETV0177
                                                                            RETV0178
                                    DETERMINE THE NUMBER OF BLOCKS
       STOP
                                    ALLOW 15 PTS TO BE GUT OFF BEFORE
                                                                             RETVOLTS
 C
                                    STARTING A NEW STRIP OF BLOCKS
                                                                             RETV0180
 C
                                                                             RETV0181
 C
       NHOR=((ICSTOP-ICSTRT-15)/41)+1
                                                                             RETV0182
 25
                                    RESET ENDING COLUMN
                                                                             RETV0197
 C
       ICSTOP=NHOR +41+ICSTRT-1
                                                                             RETV0184
       IF (ICSTOP.LE.824) GO TO 26
                                                                             RETV018
                                                                             RETV018F
       NHOR=NHOR-1
                                                                             RETV0187
       GO TO 27
       NVERT = ((IRSTOP-IRSTRT-15)/41)+1
                                                                             RETV0185
 26
        IPSTOP=41 = NVERT+IRSTRT-1
                                     SET STARTING AND ENDING PTS IN ILINE
                                                                             RETV018
                                                                             RETV019
        IPSTR=(ICSTRT-1)*4
                                                                             RETV019:
        JPEND=_CSTOP*4
                                                                             RETV019
                                     WRITE OUT NO OF BLOCKS AND STOPS
                                                                             RETV019
 C
        WRITE(6,28) NHOR, NVERT, IRSTOP, ICSTOP
                                                                             RET/019'
        FORMATI NUMPER OF HORIZONTAL PLOCKS .S . . 15/
                                                                             RETV019
  28
               . NUMBER OF VERTICAL BLOCKS IS .. 15/
                                                                             RET.V019
                                         IS NOW .16/
               * REVISED STOPPING ROW
                                                                             RETV019
               · REVISED STOPPING COLUMN IS NOW . 16)
                                                                             RETV019
                                                                             PETV019
  C
                                                                              RETV020
        ***** SECTION II --- PROCESS THE ERTS DATA TAPE *****
  C
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# -12-74 18.974 ERTS RETRIEVAL PROGRAM

			RETV0201
3		PART 1READ THE DATA	RETVOZOZ
Č		GO THRU EACH VERTIGAL BLOCK	RETV0203
3 C C		GO THRO EACH VERTICAL	RETV0204
	DO 29 IN=11.14		RETV0205
29	REWIND IT		RETVOZOS
	DO 100 LINE=IRSTRT, IRSTOP		RETV0207
	CALL EPEAD(ILINE.LN)	CHECK FOR ERROR	RETV0209
C		CHECK FOR ENASA	RETV0209
	IF (LN.NE.D) GO TO 90		RETV0210
	WRITE (6,80) LN	ERMINATED EOF DETECTED ON ERTS TAPE.)	RETV0211
80	FORMAT(/// ***EXECUTION IT	EKM-NATEDEOF DETEGOTED	
	GO TO 301	WRITE NHOR REGORDS ON DISC, ONE DISC	RETVOZLS
C		PER BAND	RETVO214
C			RETV0215
90	CALL WRTDSK(ILINE, NHOR, IPS	1K4* PEND LIDARIO	RETV0216
100	CONTINUE	PART 2 OUTPUT THE DATA	RETV0217
C		SET UP NO OF TIMES AND DISC F-LE CODE	RETV021°
C		SET OF NO OUR TENED THE SET OF	
	NTIMES=1	수요 얼마나 하는 아니라 그리는 말이 하는 게 되었다.	RETV0220
	NOSK=10+NEAND-1		RETV0221
	IF (NBAND.NE.5) GO TO 250	일이 뭐 하면데 나는 사람이 보니 아이를 가는 문화하는 것이다.	RETVOZZZ
	NTIMES=4		RETVOZE
	NDSK=10	GO THRU ONE TIME FOR EACH-BAND	RETVN224
C			RETV0225
250	DO 300 ITIME=1,NTIMES .	인물들은 이 사람이 살려가 되는 것이 있으라고 하게 했다.	RETV022(
	NDSK=NDSK+1	OUTPUT THE PICTURE FOR THIS BAND	RETV0227
C		QUAN, NHOR, NVERT, NOSK)	SETVOSSE
		MOTTE BILL IN SKETTIONS	RETV022
C	TOSTOT	RSTOP. NHOR. NOSK, PRNT, TAPE, IFL.)	RETV0231
tang pang	CALL RODSK2 (IMAGE TEST (1)		RETV023:
300	CONTINUE	GO BACK FOR ANOTHER RUN	RETV0232
C			RETVD23.
301	IF (TAPE) ENOFILE IFIL	호텔 맞았다니까, 중에 한번 중에 시간하는 그리고 오래 된다. 모음화다	RETV023
	WRITE(6,302)	OUN VAHAY	RETV023
302	FORMAT (//// END OF THIS		RETV023
	GO TO 1001	그리아는 어느 얼마 하게 되었다. 그는 그리 아들에 어느 그렇다	RETV023
	HEROTERS IN THE THE PROPERTY OF THE PROPERTY O	됐으고 들면 되었다면 됐으면 되었습니다. 나는 바로 보고 그렇게 되고 그렇게 하다 하다.	

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# REPRODUCIDILITY OF THE ORIGINAL PAGE IS POOR

PAGE

2

FRTS READIN	S PROGRAM-	EREAD, ESKIP, EINIT	<b> </b>
		RESEARCH. INC.	
, , , ,			ERTS000:
1	LBL	ERTS ERTS TAPE READING PROGRAM	ERTS000.
2	TIL	ERTS READING PROGRAM-EREAD, ESKIP, EINIT	ERTSOOO
3	TTLS	FOR CENTER FOR RESEARCH. INC.	ERTSOOO
4		DATE 9/11/72	ERTSONO
<b>C</b> #			ERTS000
6 * 0	ALLING SEG	DUENCES ARE	ERTS000:
7 *			ERTSOOO
8 * T	O INITIALI	( <b>:2E</b>	ERTSOUG
9 *			ERTS 00 1
10 *	CALL	EINIT (NOLS)	ERTS DO 1
11 *		THE THE CO THAT DATA MAY	ERTS001
12 +	EINIT I	INITIALIZES THE ERTS TAPE SO THAT DATA MAY	ERTSU01
13 *	BE REAS	D. IT RETURNS THE NUMBER OF WORDS PER	ERTS001
14 *	SCAN L	THE IN THE VARIABLE HOLS.	ERTS001
15 *			ERTS 001
16 *	TO SKIP A	NUMBER OF RECORDS	ERTS001
17 *			ERTS001
18 *	CALL	ESKIP (NOSK)	ERTS001
19 *		S THE NUMBER OF RECORDS TO SKIP.	ERTS002
20 🕶	NO2K I	END OF FILE IS ENCOUNTERED BEFORE NOSK RECORDS	ERTS 002
21 *	IF THE	IPPED, EREAD IS ABORTED.	ERTS 002
22 *	ARE SK	The first the state of the stat	ERTS002
23 *	TO 0540 4	ranger of the community	ERTS002
	TO READ A		ERTS002
25 *	CALL	EREAD (I, LN)	ERTS002 ERTS002
26 *	UNCE		ERTS002
27 <b>*</b> 28 ₹	•	THIS IS THE ARRAY INTO WHICH THE NOLS WORDS OF DATA	
29 ¥	FROM A	. The second data is divising the swift to readed in a	ERTS003
30 +		LODAL THE CTANDARD CORRESPONDING FOIRS FOR "	ERTS003
31 *	0116 60	ATO CATA MAS FOUR CHANNELS TO THESE HAS	ERTS 003
32 <del>*</del>	ACTUAL	LY NOLS/4 DATA POINTS PER SCAN LINE.	THERTS 003
33 *		THE TO TO DETRICHED BY THEFTILE IF IN ITS ALLOWED TO THE TOP	ERTS003
34 *	END OF		ERTS003
35 *	PETHEN	VED NON-ZERO, THEN IT 15 THE LINE NORSER	ERTS003
36 *	OF THE	E LINE OF DATA RETURNED.	ERTS 003
37 <b>+</b>		- THE ERTS TAPE MUST HAVE FILE CODE "ES" FOR	ERTS 003
38 *	NOTE-	THE ERIS TAPE HOST HAVE I TEL DOSE	ERTS003
39 *	THIS	PROGRAM. • •	ERTS 004
40 *		CODES POSSIBLE FROM THIS SUBROUTINE ARE-	ER15004
41 ▼		PARKS DUESED TRAINT IN NULL ENGINEER	ERTS 004
42 *	MB	FOR A BLOCK OF ERTS DATA. IT MUST BE INCREASED	ERTS004
43 *	*==	IN SIZE.	ERTS004
44 *			ERTS 004
45 *	AI	STREET WAS NOT CALLED BEFORE CALLING EXCAD ON LON-	ERTSOOL
46 *	NI UE	TO THE PRODUCTED WHILE A PART OF THE PRODUCT	ERTS 004 ERTS 004
47.*	UE	TO ON AUMOTATION RIDEKS ON EXISTANCE	ERTS004
48 <b>*</b> 49 <b>*</b>	EF	END OF FILE ENCOUNTERED WHILE IKING TO SALE	ERTS005
50 <b>*</b>		RECORDS ON ERTS TAPE IN ESKIP.	
200 - 100 <b>- 25</b> 0 10		있는 중요. 다른 아이들은 중요. 그리고 한 동요 그리고 보았다면 하는 모든 이렇지는 모든 이렇지 때문에 보다면서 보면 하는데 이렇게 하나 다른 사람들이 되었다면 다른 사람들이 되었다면 하는데 다른	

#### STORAGE

54 55 56 57 58 59 60 61 63	CNT1 CNT2 CONT EOFA	OFC OFC VFD FILCB IOTO IOTO LOTO LDQ MME RSS BSS BSS	THIS IS NONZERO IF EINIT HAS BEEN CALLED  THIS IS THE CURRENT LINE NO.  18/FCB.1/0.1/1.2/0.1/0.1/1  FCB.ES10241.1  DCH FOR READING ID  DATA.39  DCH FOR READING ANNOTATION BLOCK  DATA.**  CHOCK FOR READING DATA BLOCK  CHOCK FOR READING DATA	ERTS0054 ERTS0055 ERTS0056 ERTS0057 ERTS0058 ERTS0059 ERTS0060 ERTS0061 ERTS0062 ERTS0064
66	STS ST STK	TALLY BSS BSS	STK,4 STACK TALLY  STACK TALLY  STACK AREA	ERTS0065 ERTS0066 ERTS0067

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# ORIGINAL PAGE IS POOR

ERI	IS READING	PROGRAM	-EREAD, ESKIP, EINI	T ORIGINAL PAGE IS POOR	PAGE	5
	EINIT					
	69 EINIT	SAVE				ERTS0069
						ERTS0070
	70	SZN	EINIT	HAVE WE BEEN CALLED BEFORE		ERTS0071
	71	TNZ	EABTA	YES MARK THAT WE'VE BEEN HERE ONCE		ERTS0072
	72	STC1	EINIT	MARK 1441 HE VE SEER HERE SHOEL		ERTS0073
	73	EAXO	2,1* EIP	SAVE ADDRESS		ERTS0074
	74 75	STX0 Call	OPEN (FDW.1) OF	PEN FILE	•	ERTS0075
	(3	UALL	OI LIN (I D II V Z I			
						ERTS0076
**************************************	76	CALL	READ (FCB, CNT1)	READ ID RECORD		
		CALL	WAIT(FCB,EOFA)	AND WAIT FOR IT TO GET DONE		ERTS0077
				그들은 이번 이번 시간에 가는 항목을 받았다.		ERTS0078
	78	LDQ	DATA+3	GET REGORD LENGTH		ERTS0079
	79	ANQ	=0177777,DL	ISOLATE IT	>	ERTS0080
	80 EIP	STO		GIVE IT TO CALLER	$\theta$ .	ERTS0081
	81	QLS	6+18	SAVE TALLY COUNT		ERTS0082
	82	STCQ	ADDCNT+70 6+18-1	MULTIPLY BY 2		ERTS0083
	83 84	DIV	9,04	AND DIVIDE BY 9		ERTS0084
	85	ARL	0	IS REMAINDER ZERO		ERTS0085
	86	îZE	*+2	a YES - Parantal and Bulletin and Artis		ERTS0086
•	87	ADQ	1,0L	NO. SO INCREMENT QUOTIENT		ERTS0087 ERTS0088
	88	CMPQ	1025,DL	IS IT TOO BIG		ERISO089
	89	TNC	++3	i NO		E4130007
	90	·1 DO	=3HOMB.OL			ERTS0090

ERTS00 96 WAIT (FCB, EOFA) WAIT ON IT 96

YES, SO ABORT

SAVE IT IN DOW

CATA.9 SNAP OUT ID BLOCK READ(FCB,CNT2) READ ANNOTATION BLOCK

ERTS0091

ERTS0092

ERTS0093

ERTS0094

ERTS0095

90 91 92

93

94

95

· LDQ.

MME

STCQ

MME

ZERO

CALL

=3HOMB.DL

GEBORT

CONT. 07

GESNAP

# ERTS READING PROGRAM-EREAD, ESKIP, EINIT

EINIT

97 98 99	ESKIP	MME ZERO RETURN SAVE	GESNAP DATA,139 EINIT	SNAP OUT ANNOATION BLOCK AND RETURN	ERISUO 9 ERISOO 9 ERISOO 9 ERISU10
					er al rije. Nedaga set ale sekele e e e e e
					ERTS010
101		SZN -	.EINIT	ARE WE INITIALIZED	ERISOLO
102		TZE	EABT3	NO	ERTS010
103		LDQ	2,1*	GET NUMBER RECORDS TO SKIP	ERTS 01C
104	ECOMP	TZE	ESKR	NONE TO DO. SO RETURN	ERTS010
105		CMPQ	54+DL	IS II > 63	ERTSOIU
106		TRC	ESK64	YES INCREMENT RECORD COUNT	ESTSOLC
107		ASQ	RECNO.	INGREMENT RECORD COOK	ERTS010
108		EAX1	0,QL *+5	이 살이 되는 물통이 이 사람이 맞아 하는 것 같다. 이 기사	ERTS010
109		STX1	FSREC (FCB, .E	SKTP.FOFS)	ERTS011
110		CALL	FSKEGTI ODJAL		
				REPRODUCIBILITY OF THE	
				ORIGINAL PAGE IS POOR	
				OF ICTIVATION TO TOOM	
				있는 경찰에 어디에 이번 보고 있는 바다가 없다. 그렇다라고 있는	ERTS011
111	ESKR	RETURN	ESKIP	as account to CVID	ERTS 011
112	.ESKIP	388	1	NO. OF RECORDS TO SKIP	
		_		UNEXPECTED EOF	ERTS 011
	EOFS	רטט	=3HOEF.DL		ERTS011
114		MME	GEBORT		ERTSO1:
			CIP 64 OR MORE		ERTS011
	ESK64	LDA	63,DL	INCREMENT RECORD COUNT	ERTS011
117		ASA	RECNO.	이 의 호에 한민 나타는 걸린이 하고만 하나지 않는데 하루를 받다	ERTS011
118		SPQ	.ESKIP	SAVE FOR LATER	ERTS01:
119		CALL	FSREC (FCB, 63		0ERTS01?
121		LDQ	•ESKIP		ERTS01;
122		TPA	ECOMP	를 맞고 있다면 그는 말이 되는 하다를 보다면 하다. 네일시스 물일다	ERTS01:
	3 #			소리, 화면 하다는 이 나는 사람들은 이 날, 살고 가려면 목록했다.	ERTS017
	4 EABTA	L DQ	=3HOAI.OL	TRIED TO CALL EINIT THICE	ERTSOLI ERTSOLI
12	en a maria de la companya de la comp	MME	GEBORT	얼마 나왔던데 되는 얼마나 얼굴하는 말이 없어 있다. 사용하는 사용하다	ERISO12
12	6 EABTB	LDQ	=3HONI.DL	DIDN'T CALL EINIT	

ERTS READING PROGRAM-EREAD, ESKIP, EINIT

.

PAGE

7

EINIT

MME

GEBORT

ERTS0127

EREAD				•
29 EREAD	SAVE			ERTS0129
EA EVEND	JATT.			
30	SZN	.EINIT	ARE WE INITIALIZED	ERTS0130
31	TZE	EABT3	NO CONTRACTOR OF THE CONTRACTO	ERTS0131
32	EAQ	2,1*	GET ARRAY ADDR.	ERTS0132
33 ADDONT		**,DL	ADD TALLY COUNT	ERTS0133 ERTS0134
34	STO	OT	AND SAVE IT	ERTS0135
35	EAQ	DATA		ERTS0136
36	STQ	IT	SET UP INPUT TALLY	ER (50137
37	EAXO	3,1*	INSERT ADDRESS OF COUNT WO	ERTS0139
.38	STXO	ERP		ERTS0139
.39	CALL	READ (FCB, CONT)	READ NEXT LINE OF DATA	
.40	CALL	WAIT (FCB, EOF)	WAIT ON IT	ERTS0140
41	AOS	RECNO.	INCREMENT LINE NO.	ERTS0141
42	r DO	RECNO.	GET LINE NO.	ERTS0148 ERTS0148
43 ERP	STQ	- <b>**</b>	RETURN TO CALLER	ERTS014
44	STZ	LINIT	INITIALIZE EXPANDER	ERTS014
45 NEXT	LDQ	STS	<u> </u>	ERTS014
46	STQ	ST	INITIZE STACK TALLY	ERTS014
47 NXTONE			GET POINT	ERTS014
48	STA	OT.ID	AND PUT IT IN ARRAY	ERTS014
49	ITF	*+2	TERROR	ERTS015
150	DRL		ERROR GET NEXT POINT	ERTS015
L51	TSX1		PUT INTO STACK TALLY	ERTS015
152	STA	ST,ID NXTONE	GO PROCESS NEXT	ERTS015
153	ITF.	SIS	TALLY RUNOUT	ERTS015
154	LDQ	ST	SO REINITIALIZE TALLY	ERTS015
L55 L56 AGAIN	STQ LDQ	ST.ID	PICK UP POINTS	ERTS015
157	TIF	MORE	GOT ONE	ERTS015
158	STQ	01.10	TALLY RUNOUT	ERTS015
159	TTF	NEXT	GO PROCESS NEXT EIGHT POINTS.	ERTS015 ERTS016
160	RETURN	EREAŬ	TALLY RUNOUT, SO WE'RE DONE.	ERTS016
161 MORE	STQ	01.10	SAVE IT	ERTSU16
162	TTF	AGAIN	GO GET NEXT ONE STACKED	ERTS016
163	DR!	in san Elia Antilio di attanenta.	ERROR	(B. B. S. S. C. C. S. S. C. 프랑스리 및 T. 트립

#### POINT FETCHING ROUTINE L

	000	OR SAVED FROM LAST TSX1 L	ERISUL65
165 LSAVE		SHIFT INDICATOR FOR L	ERT50166
166 LINIT	8SS 1	STIFF INDIGNIES AND A	ERTS0167
167 *		ARE HE READY FOR NEXT PAIR	ERTS0168
168 L	SZN LINIT		ERTS0169
169	TNZ LCONT	YES	ERTS0170
170	LDQ IT.IJ	NO, SO GET NEXT WORD	ERTS 0171
171	AOS LINIT	INCREMENT LINIT	ERTS 0172
172	TRA LRET	DONE FOR THIS ONE	- , , ,
173 LCONT	AOS LINIT	INCREMENT AGAIN.	ERTS0173
174	LDQ LINIT		ERTS0174
1/5	CHPQ 5.OL	IS THIS 5TH TIME	ERTS0175
177	TZE LS	YES	ERTS0176
176		OR 9TH TIME	ERTS0177
177	· ·	NO THE RESERVE OF THE	ERTS0178
178	TNZ #+2		to the same of the
	0.0000 8.000 <b>0110</b> 8.000	REINITIALIZE	ERTS0179
179	STZ LINIT		ERTS0180
180	LDQ LSAVE	GET SAVED QR	ERTS0181
181 LRET	LDA 0.DL		ERTS0182
18?	LLS 8	SHIFT OVER	ERTS0183
183	STQ LSAVE	SAVE OR FOR NEXT TIME	ERTS0184
184	TRA 0.1	AND RETURN	
185 L5	LDA O.DL		ERTS0185
186	LDQ LSAVE	RESTORE QR	ERTS0186
187	LLS 4	THIS ONE IS DIVIDED OVER	ERTS0187
	LDO IT,ID	WORD BOUNDARIES	ERTS0188
188	LLS 4		ERTS0189
189			ERTS0190
190		RETURN	ERTS0191
191	TRA 0.1		ERTS0192
192 *			ERTS0193
	OF PROCESSOR FOR EREAD	Ware Con To Call Co	ERTS0194
194 EOF	STZ ERP.I	HARK EOF TO CALLER	ERTS0195
195	RETURN EREAD	AND RETURN	

196 END TION. PA 091572/091472 JMPB 053172/070872 IN THE ABOVE ASSEMBLY

JMPC 072772/072772

ERTS0196

	SPECIAL PICT	DOC DOUTINE	IXEYOUL
CPIXFY	Shentur , to.	and the control of th	IXEADUS
С	CM DA DAGLEY	JAN 131 T	PIXEY003
C	MEITTEN BY RJ BOSLEY	in the second	PIXEY034
C			PIXFYOOS
C	DESCRIPTION OF PROGRAM.		SIXLADDE
C			>1XFY007
C	SPECIFIED PAPAMETERS TO	O KOLSKP ALL MUST BE SUPPLIED TO THIS	
C	THE PARAMETERS LINSKIP AND	ELIST SPICTUR FORMAT. FOR A COMPLETE	PIXEYOUS
	SUSPROGRAM UNDER THE NAME	MENTS TO PITCHR. SEE THE PITCHR WRITEUP.	PIXEYU10
C			
C	BY THE USER SETTING LINAX		PIXFY01:
C	POSSIBLE 10 OBIATA A PUS		PIXEY013
C	NOTE-DISC FILES MUST	SE ON LECT GOODS TO	PIXEA017
C			<b>PIXEADT:</b>
C	INTERNAL PARAMETERS.	DAND NIMARE BEING MAUCESS /	PIXEYD10 :
C	IBAND	STARTING FNOING BAND NUMBERS	PIXEY017
C	IS.IE	MIMPED OF LINES IN IMAGE PRINTED	PIXEY01
C	LINES	MIMAGO OF LINES TO SKIP IN EXISTANCE	PIXEY 11'
C	NOSK	STARTING, ENDING POINTS IN ERTS LINE	PIXEY02'
C	IPSTR, IPEND	LINE AND COLUMN INCREMENT	PIXFY02
C	LNSKIP, KOLSKP	COLUMN INCREMENT FOR ERTS LINE	PIXEY92
C	ISKIP	NUMBER OF COLUMNS IN IMAGE	PIXEY02
C	KP	MONDER OF GOESTIVE OF T	PIXFYUZ
C			PIXEY05
C	INPUT ARGUMENTS TO PITCH	ARRAY TO BE PRINTED	PIX EYO 2
C	IMAGE	nee of boug cols IN ARRAY	<b>BIXEAOS</b>
C	ICELL, JCELL	NUMBER OF TIMES ENTRY IS MADE AT SNAP	<b>BIXEA05</b>
C	INIT	MUST OF GREATER THAN 1	E T V C 4 3 C
C		MENTHUM MAYTHUM MRFY TONES IN ARRAY	PIXEY03
C	IMIN.IMAX	NUMBER OF ROWS TO BE PRINTED=1UELL	DIXEA03.
C	NROW	oe ourphy FT: FS AVAILABLE.	PIXEY03;
C	NFILES	SET=0 FOR ALL OUTPUT ON FILE CODE 6	PIXEY03
C	na na salah kara da kata basar	cer-2 FOR FILES 06 AND 42	PIVEL 22
C		TE GT 2. USER MUST SUPPLY FILES	PIXEY03
C		ADDAY CONTAINING OUTPUT FILE CODES	PIXEYD3
C	IFIL _	MILLIOSO OF COLS-ROWS PER OUTPUT PAGE	PIXEY03.
C	NULW, NULD	WIDTH, LENGTH DOWN MAGNIFICATION	PIXEY03
C	AMAG, DMAG		PIXFY03
C		아들의 회사는 사이는 이 얼룩된 것으로 그는 그 것이 이렇게 다	PIXEY04
C	ENTRY POINT.	GE, IRSTRT, IRSTOP, ICSTRT, ICSTOP, QUAN, NBAND)	PIXFY04
C	CALL PIXEA (TITINE+THAT	# 5,500 to 10 to 1	
C			PIXEY04
C	INPUT ARGUMENTS.	ARRAY ERTS LINE IS READ INTO	PIXFY04
C	THE THINE	TWACE ARRAY FOR PITCHR, HOLDS ONE LINE	PIXEY34
C	IMAGE	CTARTING STOPING ROW IN IMAGE	PLAKE FUR
C	IRSTRT, IRSTOP	ATABETIC STOPING TOLL IN IMAGE	PIXEY04
C	ICSTRT.ICSTOP	TRUE FOR EQUAL PROBABILITY QUANTIZING	PIXEY04
C	A A B CONTRACTOR OF THE SECOND		F 1 V 1 1 1 2 7
C	[연주] : 14 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	BAND NUMBER TO BE PROCESSED	PIXEY05
•	NRAND	이 있었다. 목록하셨는 경험하고 했다는 경기는 환경 그렇지 일본 때는 이미터, 이를 되어 모든 말하다.	

```
PIXCY051
                                      SET=5 FOR ALL BANDS
                                                                            PIXEY052
C
                                                                            PIXEY053
      EXAMPLE OF SAMPLE RUN.
C
                                                                            PIXEY054
         CONTROL CAPOS --
C
                                                                            PIXEY055
           SPARAM SPIC=T,QUAN=T,IRSTRT=1,IRSTOP=1216,ICSTRT=5,
C
                                                                            PIXEY156
            ICSTOP=772, NGAND=23END
           SPICTUR INIT=304.NFILES=2.LNSKIP=4.KOLSKP=3.JCELL=2568EN0
                                                                            PIXEY057
         THIS PUN WILL PRINT OUT ON FILES OF AND 42 A PICTURE 256 PTS
                                                                            PIXEY059
      WIDE BY 304 LINES. NOTE THAT 1216/4=304 AND 768/3=256. GIVING THEPIXEY059
      VALUES FOR LNSKIP=4.KOLSKP=3.JCELL=256.INIT=304. ALSO, USING
                                                                            PIXEYU60
                                                                            PIXEYU61
      THESE VALUES FOO LASKIP AND KOLSKP. THE PICTURE WILL BE IN-
                                                                            PIXEY062
      PROPORTION TO THE ERTS PRINT.
C
                                                                            PIXFY063
C
                                                                            PIXEY064
      SUBROUTINE PIXEY (ILINE, IMAGE, IRSTRT, IPSTOP, ICSTRT, ICSTOP, QUAN,
                                                                            PIXEY065
                                                                            PIXEY066
                               KONAEN
                                                                            PIXEY067
                                                                            PIXEY068
      DIMENSION ILINE(1), IFIL (10), IMAGE(1)
                                                                            PIXEY069
      LOGICAL QUAN
      NAMELIST /PICTUR/NFILES, IFIL, ICELL, JCELL, INIT, IMIN, IMAX, NROW.
                                                                            PIXEY070
                         NULW, NULD, AMAG. DMAG, LNSKIP, KOLSKP
                                                                            PIXEY071
                                                                            PIXEY072
                                    INITIALIZE PARAMETERS
C
                                                                            PIXEY073
      ICELL=1
                                                                            PIXEY074
      JOELL=256
                                                                            PIXEY075
      INIT=304
                                                                            PIXEY076
      · IMIN=0
                                                                             PIXEY077
      IMAX=75
                                                                            PIXEYU78
      IF (QUAN) IMAX=12
                                                                             PIXEY079
      NFILES=?
                                                                             PIXFY080
      IFIL(1)=6
                                                                             PIXEY031
       IFIL (2)=42
                                                                             PIXEY092
      NROW=ICELL
                                                                             PIXEY083
      NULW=129
                                                                             PIXEY084
      NULD=60
                                                                             PIXEY085
      AMAG=1
                                                                            PIXEY086
       DMAG=1
                                                                             PIXEY087
       LNSKIP=4
                                                                             PIXEY088
       KOLSKP=3
                                                                             PIXEY089
                                     READ PARAMETERS
C
                                                                             PIXEY090
       READ (5, PICTUR)
                                                                             PIXEY091
                                     WRITE OUT PARAMETERS
C
                                                                             PIXEY092
       WPITE (6,1)
                                                                             PIXEY093
       WRITE(6,PICTUR)
                                                                             PIXFY894
       FORMATI///20X. SPECIAL PICTURE ROUTINE .///
                                                                             PIXEY095
       FORMAT (1H1. BAND NUMBER . 11)
 2
                                                                             PIXEY096
                                     SET UP FOR THE DESIRED BAND
                                                                             PIXEY097
       IS=1
                                                                             PIXEY098
       IF=4
                                                                             PIXEY099
       ISKIP=4*KOLSKP
                                                                             PIXEY 100
       IF (NBAND. EQ. 5)
                        GO TO 5
                                       REPRODUCIBILITY OF THE
                                       ORIGINAL PAGE IS POOR
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# REPRODUCIBILITY OF THE ORIGINAL PAGE IS POOR

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#### SPECIAL PICTURE ROUTINE

	IS=NPAND	PIXFY101
	IE=IS	PIXEY102
С	GO THRU EACH BAND	PIXEY103
5	DO 100 IBAND=IS.IE	PIXFY104
	REWIND 13	PIXFY195
	PEWIND 14	PIXEY105
C	WRITE SUBTITLE	PIXFY107
Ų	WPITE (6.2) IBAND	PIXEY108
	IPSTR=(ICSTPT-1)*4+IBAND	PIXEY119
	TPEND=TCSTOP#4	PIXFY110
C	INITIALIZE SNAP IN PITCHR	PIXEY111
•	CALL PITCHR (IMAGE, ICELL, JCELL, INIT, 1, IMAX, IMIN, NROW, NFILES, IFIL.	PIXEY112
	NULW, NULD, AMAG, DMAG.)	PIXEY113
С	POSITION THE INPUT TAPE	PIXEY114
•	NOSK=IRSTRI-1	PIXEY115
	CALL EPEWND	PIXFY116
	IF (NOSK.NE.O) CALL ESKIP (NOSK)	PIXEY117
C	GO THRU EACH LINE	PIXEY118
U	DO 50 LINE=IRSTRT, IRSTOP, LNSKIP	PIXEY119
C	READ LNSKIP LINES	PIXEY120
· ·	DO 10 LIN=1, LNSKIP	PIXEY121
	CALL EREAD(ILINF, LN)	PIXEY122
	IF (LN.NE. 0) GO TO 10	PIXEY123
	L=LINE+LIN TOTAL CONTROL OF THE STATE OF THE	PIXEY124
	CONTRACTOR ON THE CONTRACTOR OF THE CONTRACTOR O	PIXEY125
<b>.</b> 9:	FORMATIVIVE *** EXECUTION TERMINATED EOF DETECTED ON ERTS TAPE.	PIXEY126
7	1LINE NUMBER IS . 16/141)	PIXEY127
	RETURN	PIXEY128
4.0	CONTINUE	PIXEY129
10	GET THIS LINE FOR THE IMAGE	PIXEY130
С	KP=0	PIXEY131
	00 20 IP=IPSTR, IPENO, ISKIP	PIXFY132
	KP=KP+1	PIXEY133
	IMAGE(KP)=ILINE(IP)	PIXEY134
20	CONTINUE	PIXFY135
20	WRITE THIS LINE TO SCRATCH FILE 14	PIXEY136
C	WPITE(14) (IMAGE(IP), IP=1, JCELL)	PIXEY137
<b>.</b>	CONTINUE	PIXEY138
50	ENDFILE 14 CARREST AND THE RESERVE AND THE RES	PIXEY139
		PIXEY140
	REWIND 14 QUANTIZE FILE 14 AND PUT OUT ON 13	PIXEY141
C	IF (QUAN) CALL ZEQUAN (IMAGE, INIT, JGELL, 1, 1, 1, 13, 14, 13)	PIXEY142
	REWIND 13	PIXFY143
	READ THE QUANTIZED IMAGE	PIXEY144
C	그는 사람들은 그는 그를 가는 것이 되었다. 그는 그를 가는 사람들은 사람들은 그를 하면 하는 것은 사람들은 사람들은 사람들은 사람들은 사람들은 사람들은 사람들은 사람들	PIXEY145
	DO 90 I=1,INIT READ(13) (IMAGE(K),K=1,JCELL)	PIXEY146
	SNAP OUT THIS LINE	PIXEY147
C	我看到一点,我们也没有一样的,我们没有好的。我们的人,我们的人,我们的人,我们没有的人,我们就会没有了。""我的我们,我们的是是不是,我们的人,我们会会会会,不	PIXFY148
90		PIXEY149
100	나 CONTINUE 이 그녀를 가득하고 말을 하는데 하다 모든 것이 있는데 물로 가장 사람들은 함께 없는데	PIXEY150
	그 마루트 (URA) - 이 교통 문제가 이 프로그램을 가능하는 것을 받는데 보고 있다. 	
H 362 X.15 .	는 MENO (18 H. 18 H. 19 H. 19 H. 19 H. 18 H. 19 H. 18 H. 18 H. 18 H. 18 H.	

ZEQUANN1

ZEDUAN41

ZEQUAN41 ZEQUAN42

ZEQUAN43

ZEQUAN44

ZEDUAN45 ZEQUAN46

ZEQUAN47

ZEQUAN48

ZEQUAN49

ZEQUAN5

19.149 02-12-74

ZEQUAN

```
ZEQUAN
                                                                              ZEQUANDZ
CZEDUAN
                                                                              ZEQUANO3
                                                                SEPT 1973
      MODIFIED FROM KEQUAN BY Z DINSTEIN
                                                                              ZEQUANO4
C
                                                                              ZEQUAN05
C
      DESCRIPTION OF PROGRAM.
         THIS SUBROUTINE QUANTIZES AN IMAGE ON FILE "INFILE" BY EQUAL
                                                                              ZEQUAND6
      PROBABILITY TO ME LEVELS AND OUTPUTS IT TO FILE ! THIS PROCESSING IS DONE LINE BY LINE AFTER A FIRST PASS IS MADE THRU
                                                                              ZEQUANO?
                                                                              ZEQUANDS
      THE IMAGE TO DETERMINE THE MINIMUM AND MAXIMUM GREY TONES.
                                                                              ZEQUAN99
                                                                              ZEQUAN10
                                                                              ZEGUAN11
      ENTRY POINT.
          CALL ZEQUAN (LINE, NUMLIN, NUMPPL, NCOMP, ICOMP, LEFT, NQ, INFILE,
                                                                              ZEQUAN12
                                                                              ZEQUAN13
                                 IOUTFL)
                                                                               ZEQUAN14
                                                                               ZEQUAN15
      INPUT ARGUMENTS.
                                                                               ZEQUAN16
               LINE = ARRAY ONE LINE OF IMAGE IS READ INTO
                                                                               ZEQUAN17
                NUMLIN= NUMBER OF LINES IN IMAGE
                                                                               ZEQUAN18
                NUMPPLE NUMBER OF COLUMNS IN IMAGE
                                                                               ZEQUAN19
                NOOMP = NUMBER OF COMPONENTS IN ORIGINAL IMAGE
                                                                               ZEQUAN20
                ICOMP = THE COMPONENT TO BE QUANTIZED
                                                                               ZEQUAN21
C
                LEFT = LEFT-MOST CELL IN LINE DESIRED
                                                                               ZEQUAN22
                      - NUMBER OF QUANTIZED LEVELS
                INFILE = INPUT FILE CONTAINING IMAGE TO BE QUANTIZED
                                                                               ZEQUAN23
                                                                               ZEQUAN24
C
                                                                               ZEQUAN25
 C
       OUTPUT ARGUMENTS.
                IOUTFL= OUTPUT FILE CONTAINING QUANTIZED IMAGE
                                                                               ZEQUAN25
                                                                               ZEQUAN27
                                                                               ZEQUAN28
 C
       SUBROUTINE ZEQUAN(LINE, NUMLIN, NUMPPL, NCOMP, ICOMP, LEFT NQ, INFILE,
                                                                               ZEQUAN29
 C
                                                                               ZEQUAN30
                IOUTFL)
                                                                               ZEQUAN31
                                                                                ZEQUAN32
 C
        DIMENSION LINE (NCOMP, 1) , KN (512)
                                                                                ZEQUAN 33
                                      INITIALIZE HISTOGRAM TO ZERO
                                                                                ZEQUAN34
 C
        DO 1 I=1,512
                                                                                ZEQUAN35
                                                                                ZEQUAN36
        KN(I)=0
                                                                                ZEQUAN37
        CONTINUE
 1
                                                                                ZEQUAN38
        MIN=10000
        M4X=-10000
                                                                                ZEQUAN39
        REWIND INFILE
                                      GO THRU EACH LINE
        DO 2 II=1.NUMLIN
        READ (INFILE) ((LINE(J,L), J=1,NCOMP), _=1,NUMPPL)
                                      SET STARTING, ENDING PTS IN LINE
        IRIGHT=LFFT+NUMPPL-1
        DO 2 I=LEFT. IRIGHT
        J=LINE(ICOMP.I)
                                       GET MIN, MAX AND HISTOGRAM
        IF (MAX.LT.J) MAX=J
        IF (MIN.GT.J) MIN=J
        KH (J+1) = KH (J+1)+1
```

### MIRRODUCIBILITY OF THE ORIGINAL PAGE IS POOR/

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ZEQUAN

_	ANTINE		ZEQUAN51
2	CONTINUE .		ZEQUAN52
	NGL=MAX		ZFQUAN53
	WRITE(6,100) MIN,MAX	P 1. A	ZEQUAN54
100	FORMAT(1X, MIN. MAX APE 1,2	GET NO OF PTS IN IMAGE	ZEQUAN55
C		UE 1 HO OF 1 15 IN THESE	ZEQUAN56
	NP=NUMLIN*NUMPPL	and the company of th	ZEQUAN57
	J=1		ZEQUAN58
	MQ=NQ	ACTEONING LEVE. C	ZEQUAN59
2	artik	DETERMINE LEVELS	ZEQUANGO
	00 3 T=1,NQ		ZFQUAN61
	N_≠NP	CON MOUNT OF THE	ZEQUAN62
C.		GET NEW LEVEL	ZEQUAN63
4	N"=NF-WG+KN(J)		ZEQUAN64
	NP=NP-KN(J)		ZEQUAN65
	KN (J) = I - 1		ZEQUANG6
		FUEL CUED	ZEQUAN67
C		IF LAST LEVEL, SKIP	ZEQUAN68
	IF(J.GT.NGL) GO TO 6	THE PARTY ACATAL	ZEQUAN69
C		INCREMENT THE LEVEL AGAIN	ZEQUAN70
	IF (MQ*KN(J).LE.NL*2)GO TO 4	THE THE NAME OF SHELF LEST	ZEQUAN71
S		DECREASE THE NO. OF LEVELS LEFT	ZEQUAN72
3	MQ=MQ-1		ZEQUAN73
	50 5 I=J.NGL		ZEQUAN74
5	KN (I) = NQ-1		ZEQUAN75
	GO TO 8	orana di kalendara d	ZEQUAN75
C	and the state of t	RESET THE LAST LEVEL	ZEQUAN77
6	N=(NQ-I)/2		ZEQUAN78
	IF (N.LT.1) GO TO 8		ZEQUAN79
	DO 7 I=1.NGL		ZEQUANSO
7	Ku (I) = Ku (I) + N		ZEQUAN81
8	CONTINUE		ZEQUANS2
C		REWIND DISG FILES	ZEQUAN83
	PEWIND INFILE		ZEQUAN84
	REWIND TOUTFL		
3		ASSIGN QUANTIZED LEVELS LINE BY LINE	ZEQUANSS
	DO 11 II=1.NUMLIN		ZEQUAN87
	READ (INFILE) ((LINE(J,L),J	:1,NCOMP),L=1,NUMPPL)	ZEQUANS8
	DO 9 I=LEFT.IRIGHT		ZEQUANS9
	J=LINF(ICOMP+I)		ZEQUANS9
9	LINE (ICOMP, I) = KN (J+1)		ZEQUAN91
C		WRITE OUT QUANTIZED FILE	ZEQUAN92
	WRITE (TOUTFL) (L'INE (ICOMP.	(),K=LEFT, IRIGHT)	ZEQUAN93
11	CONTINUE	강에게 있다면요 한 화면도 가고 사용을 받는데 뭐 모든 입니다.	ZEQUAN94
	ENDFILE IOUTFL	그는 사이가 물통하다 물어가는 경험을 하면 하고 있다. 나	
	REWIND IOUTFL		ZEQUAN95 Zequan96
	RETURN	얼마 아들아 많아 이 나는 항상을 하는데 모르는데 하는 것이다. 네트	ZEQUAN97
	ENO	그는 이 이 이 나는 아니는 아들이들이 어려워 되었다. 일하	LE MONAY

```
THREY EXECUTION PEPCAT
                                       PTCHGG
                                                                              PTCHPG
PTCHPG11
                      10.177
          13-65-71
R7544 11
                MURCHICOPAK
                                                                                     PTCHRS^2
                      FITCHR
                                                         3 4 A P
                                                                                     PTCHRG73
              TTL
                                         рттпчз
                       ENTRY POINTS ARSSET & HARG BY G ELLIOTT.
                                                                                     PTCHPG 4
              LBL
                                                                                      PTSHP635
    3
                                        TO SET RIT 35 & INITIALIZE
                                                                                      PTCHRG06
              254
                       ARGSET
                                                                                      PTCHRG:7
              SYUPEF
                                        FOR MARGE
       ARGSET SAVE
                                        SET BIT 35
                       1.UL
                                                                                      PTCHRS79
              FD3
                       GESETS
                                         TRACE BACK TO GET
               MYE
                                         LOCATION OF LAST SALL
              LOXO
                       1.1
                                                                                      PTCH=G11
     9
                       0.0
               LOXO
                                                                                      PTCHRG12
                                         TO PITCHR
    10
                                         PUT IT WHERE MARS DAN USE IT.
                       1.0
                                                                                      PTCHRG13
               EAXD
                                         GET NUMBER OF ARGUVENTS PROVIDED.
    11
                        LCCAT
               STXT
                                                                                      PTCHRG14
    12
                        -1,0
                                                                                      PT048515
               LOXA
    13
                        LOCAT
                                         ALSO FOR MARGE
                                                                                      PTSHRG16
               SELXO
STX1
                        PUZZAM
                                                                                       PTCHR317
    15
                                         ENTRY POINT TO SHECK FOR THE
                        ARGSET
               RETURN
                                                                                       PTCHRG18
                                         EXISTENCE OF MON-MULL ARGUMENTS.
    16
                        MARG
                                                                                     PTCHRG19
               SYMMER
    17
                                          WHICH ARGUMENT AREAE CHECKING ?
                                                                                       PTCHRG20
               SAVE
    18
       DFAM
                        2.1*
               LXLO
                                                                                     PTCHRG21
    19
                                          DO WE HAVE THAT MANY ?
                                                                                       PTCHRG22
                EAG
     20
                        we, DU
     21 MAXVUM CMPYC
                                                                                       PTCHRG23
                         #+3
                THI
                                                                                       PTCHEG24
                                          NO.
GO HOME.
     22
                         O.DU .
                                                                                       PTCHRG25
                52N
     23
                         , E.L.il
                                                                                     PTCH=G26
                AFT
                                          IS IT A NULL POINTER ?
                         ...
                                                                                        PTCH=327
     25 LOCAT
                EAKT
                         U.U
                                                                                        PTCHRG28
                LOXO
     25
                                                                                        PTCHPG29
                         4+2
                TVZ
     27
                                           YES
                         ELLIII
                                                                                        PTCHRG30
                TRA
     28
                                           ND
                         1. DL
                בפש
                                                                                        PTCHRG31
     29
                         ELLINI
                 T34
     30
                         APORT
                                                                                        PTCHRG33
                 SYMBEF
      31 •
                                                                                        PTCHRG34
PTCHRG35
                 855
      32 E
      33 ABORT
                 NULL
                         =3HOPT, DL
                 LDD
                          GEBBRT
                                                                                         PTCHRG37
                 YYE
      35
                                           GET ADDRESS OF ARRAY.
                 SYMPER
                         BORED
                                                                                         PTCHRG38
                          3,1*
                                                                                         PTCHRG39
      37: 803ED
                 EAXO
                                           USE FOR TALLY COUNT
                          4,1*
                                                                                         PTCHEG40
                 LDD
      38
                 GLS
      39
                          TALI
                 STO
                                            CHARACTER THAT SOES INTO ARRAY
       40
                          TALI
                                                                                         PTCH9G43
                  STXO
       41
                          = 6H=
                                                                                         PTOHRG44
                  EAXO
                                            XED WILL USE TALLY MODIFICATION
       42
                          STR-1
                                                                                         PT5-2645
                  STXO
       43
                          TW
                  EAXD
                                            START FILLING APRAY
                                                                                         PTSHRS47
                          STR
                  STX1
       45
                                                                                         PTCHRG48
                                            BUMP BCPDER POSITION
                           BCR
                  TRA
                                                                                          PTCHRG<sup>2</sup>9
                           2,1.
                  ADS
                                                                                          PTCHRGSO
                           BOR
                  TTE
       48
                           0,10
                                                                                          PTCHRGSS
                  TRA
       49
                  355
       50
          TALL
                           BORDER
```

REPRODUCIBILITY OF THE ORIGINAL PAGE IS POOR

SYYNEF

```
THREE EXECUTION REPORT
                                       PICHAG
                      15.172
R7644 01 03-05-71
                       25
                                        WE STORE ON EITJER SIDE OF IMAGE DATA
                                                                                      PTCH9653
   52 BORCER EAXIL
                      STR
                                                                                      PTCHPG54
              STXn
   53
                                        CHARACTER FOR VERTICAL BORDER
                       = 5HI
                                                                                      PTCHRG55
              EAXIT
   54
                       STH-1
                                                                                      PTCHRG56
   55
              STXT
                                        CURPENT LIKE COUNT
15 IT DIVISIBLE BY TEN
              L2:
                       2.1.
                                                                                      PTCHRG57
   56, 203
                       10,01
                                                                                      PTCHRG58
   57
                       U.PL
                                                                                      PTCHPG59
              CHPA
   58
                       ILTEN
   59
              TVZ
                       11.DL
   60
              DIV
                                         PUT BLANKS IN OF
                       BLIK
              LOU
                                        MAKE NO. LEFT JUSTIFIED, BLANK FILLED
   61
                       30
              LLS
   62
                       STR
              AFT
   63
                                     a WAS THE NUMBER DIVISIBLE BY FIVE
                       5.DL
              SMPA
                                                                                      PTCHRG55
      NTEN
                                                                                       PTCHRG56
   65
                       FIVE
              TZE
                       ..
              LDA
                                                                                      PICHRG57
   66
              XED
                       ..
                                                                                      PTCHRG68
   67 STR
                                         RETURN IF WE ENTERED AT BORDER
              TRA
                       0,1
              LDA
                       =680
                                                                                       PTCHRG70
   69 FIVE
                       STR
                                                                                       PTCHRG71
               AFT
   70
                                         PUT IN HOR RORDER ARRAY
                       TALI, ID
             ESTA
      TW
   71
                        TT
                                                                                       PTCHRG73
               TRA
   72
                                                                                       PTOHRG74
                        3/1*
               STA
    73 DS
                                                                                       PTCHRG75
               STA
                        4.10
                       LSHIFT
                                                                                       PTCHRG76
               SYMOLF
    75
                                         ADDRESS OF ARRAY
      LSHIFT EAXO
                        2.14
                                         NO, ELEMENTS IN ARRAY
               LDD
                        3,10
    77
                                         USE FOR TALLY COUNT
                        6
                                                                                       PTCHRG79
               945
    78
                        TALI
                                                                                       PTCHRGED
    79
               STO
                        TALI
    80
               STX1
                                                                                       PTCHRGS2
                        TALI, I
               LOD.
    81 LD
                                          SHIFT UP NEXT GHARACTER
                                                                                       PTCHRG93
               9.5
STD
                        6
    62
                        TALITID
                                                                                       PTCHRG84
    83
                        LD
                                                                                       PTCHRSSS
               TTF
    84
                                                                                       PTOHRESS
                        0,14
               TRA
    85
                        IFETCH
                                                                                       PTCHRG97
               SYMBEF
    86
                                                                                        PTCHRSES
               335
    87 S1
                                                                                        PTSHRGES
    88 52
               355
                                                                                        PTSHRGPD
               555
    89 53
                        2,7
                                                                                        PTEHRG91
                                        =1 FOR INTEGER, D FOR FLOATING PT
    90 IFETCH SAVE
               LXLT
                                                                                        PTCH9692
                        4,14
                                                                                        PTSHRG93
               EAXS
                        2:14
    92
                                                                                        PTCHRG94
                        GETT .
    93
                TSXO
                         51
                                                                                        PTCHRG95
               FSTR
     94 551
                                          REPRODUCIBILITY OF THE
                                                                                        PTCHRGSE
               LXLD
                         7,14
     95
                                           ORIGINAL PAGE IS POOR
                                                                                        PTCHRG97
                         .+3
                TYZ
     96
                         1 . DU
     97
                SXCA
                                                                                        PTCHRG98
                                                                                        PTCHRG99
PTCHRG80
                         GETT
     98
                TSX1
                FSTR
                         52
     99
                         6,14
                                                                                        PTCHR501
                FXTU
    100
                                                                                        PTCHRSS2
                TZE
                         ...3
    101
                         51
                                                                                        PTCHRG03
    102
                FLD
```

Ū

FS

TRA

103

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SMOEK EXECUTION REPORT
                                            PTCHAG
                         15,192
R7544 01
            03-05-71
                                                                                                 PTCHPG14
                                                                                                 PTCHRGS5
                          3 11 4
  104
                                                                                                 PTCHRG37
  105
                ADX?
                          2,1
                          GETT
                TSX
  106
                                                                                                 PTCHRG15
PTCHPG19
                F 55
                          51
  107
                FAP
                          6.1.
  108
                                                                                                 PTCHRG13
                          $1
$3
                FAD
  109
                                                                                                 PTCH=G11
  110 FS
                FSTP
                                                                                                 PTCHPG12
                          $2
                FLU
  111
112
                                                                                                 PTCHRG13
PTCHRG14
                FSB
                          51
                FYP
                          5,1*
   113
                          SI
                                                                                                  PTSHRG15
   114
                FAD
                                                                                                  PTCHRG16
                FAD
                          S3
   115
                                                                                                  PTCHRG17
PTCHRG18
                          =2,
                FOV
   116
                          FYIN
   117 FR
                F35
                                                                                                  PTCHRG19
                          FM-SS1
                EQU
   118 IE
                                                                                                  PTCHRG20
                FOV
                          FDIF
   119
                                                                                                  PTCHRG21
                 FYP
   120
                           =0..DU
                                                                                                  PTCHRG22
                 FAD
   121
                                                                                                  PTCHRG23
                 TPL
                           ++2
   122
                           =0777777777
                                                                                                  PTCHRG24
   123
                 UFA
                                                                                                  PTCHPG25
                           7101024,DU
                 JFA
   124
                                                                                                  PTCHRG26
                           1 . DL
                 DOA
                                                                                                  PTCHEG27
                           2, DL
                 CASU
    126
                                                                                                  PTCHR523
    127
128
                 TPL
                           *+3
                                                                                                  PTCHR529
                 Loo
                           1.DL
                                                                                                  PTCHP530
                           IFETCH
                 RETURN
    129
                                                                                                  PTCHRG31
                           ..,DL
    130 ID
                 CMPG
                                                                                                   PTCHRG32
                 THI
    131
                           .+2
                           ... DL
                                                                                                   PTCHRG33
                 100
        100
                                                                                                   PTCHRG34
                           IFETCH
                  RETURN
    133
                                                                                                   PTCHRG35
                           1.00
    134 GETT
                  CYPX7
                                                                                                   PTCHPS36
                  TZE
                           3,10
    135
                                                                                                   PTCHRG37
                           0.2
    136
                  FLD
                                                                                                   PTCHRG38
                           ....
    137 01
                  TRA
                                                                                                   PTCHRG39
                  LDA
                            0.2
    138
                                                                                                   PTCHRG40
                  EAD
                                                                                                   PTCHRG41
                            35 41024 100
                  LDE
    140
                                                                                                   PTCHRG42
                            =0..DU
    141
                  FAD
                                                                                                   PTCHRS43
                            ..,0
    142 02
                  AFT
                                                                                                   PTCHRG44
                  SYMMEF
                            FI
    143
                                                                                                    PTCHRG45
                            2.1.
                  FLD
    144 FT
                                                                                                   PTCHR646
PTCHR647
                  FS3
                            3,10
    145
                                                 REPRODUCIBILITY OF LITTORIES POOR ORIGINAL PAGE IS POOR
                            FOIF
     146
                  FST
                                                                                                    PTSHRG48
                            3.1.
                  FUD
                                                                                                   PTSHRG49
PTSHRG50
PTSHRG51
     147
                  FST
                            FHIN
     146
                             4,1.
                  LXLC
     149
                            IDD
                  STXO
     150
                                                                                                    PTCHRG53
PTCHRG53
PTCHRG54
                            1.04
                  LXCA
     151
                             10
                  STXD
     153
                            0
                  EAA
                                                                                                    PTCHRG55
                             -1,0
     154
                  EAG
     155
                   LLS
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		03-05-71	19,192	PTCHPG	CHREX	EXECUTION	REPORT	
R7644	^1	03-07-17				mangan ji masa 190		FYCHRG56
		. 9=	35*1124.00					PTCHRG57
156		ΓJE	=0.,00					PTCHPG58
157		FAD						PTCHRG59
158		FSTR	. E _					
159		L D D	0.2					PTCHRGSO
160		LUS	36					PTCH=G61
. 161		EXLO	5.1.					PTCH9G62
		TNZ	27					PTGHRG63
162		EAX1	ĪĒ					PTSH2G54
163			oī			na izanah di di		PTSHPG65
164	ξX	STXO						PTCHRG56
. 165	<b>i</b>	STXO	0.5					P10M100
166		174	0.1*					PTSHRG57
167	7.72	EAXO	0					PTCHPG58
168		TRA	SX					PTSHRG59
			1					PTCHRS70
169								PTSHRG71
179	FMI							PTCHRG72
17		AK BOI				역표 전 기념생 :		
4.7	<b>7</b>	EVD			5.5 1.8 25 41.5			•

REPRODUCIBILITY OF THE ORIGINAL PAGE IS POOR

```
WRTUSKO1
                    HRITE ERTS DATA ONTO DISC
                                                                             WRITOSKOS
CWRTGSK
                                                                              WRIOSKO3
                                                                JAN 1974
      VERSION II WRITTEN BY RJ BOSLEY
                                                                              WRTDSK04
Ç
                                                                              WRTCSK05
C
      DESCRIPTION OF PROGRAM.
         THIS SUPROUTINE WRITES ONE LINE OF ERTS DATA FROM ARRAY ILINE
                                                                             WRTTSKOR
      ONTO DISC FILES, ONE FILE FOR EACH BAND. DATA IS HRITTEN IN NHOR WRIDSKO7
                                                                              WRTDSK08
      BLOCKS.
                                                                              WRIDSK09
                                                                              WRIDSK10
C
      INTERNAL PARAMETERS.
                                                                              WRTDSK11
                                     DISC FILE CODE, 11 THRU 14
               NOSK
                                                                              WRTUSK12
                                     POINT INDEX FOR ERTS LINE
               TP
                                                                              WRTCSK13
C
                                     STARTING STOPING POINTS IN LINE.
               IPSTRT, IPSTOP
                                                                              WRTDSK14
C
                                       DEPENDENT UPON THE BAND
                                                                              WRIESK15
                                                                              WRTDSK16
       ENTRY POINT.
                                                                              WRTCSK17
               CALL WRTDSK(ILINE, NHOR, IPSTR, IPEND, NBAND)
                                                                              WRTDSK18
                                                                              WRTDSK19
       INPUT ARGUMENTS.
                                                                              WRTDSK20
                                     ARRAY CONTAINING ERTS LINE OF DATA
                                     NUMBER OF HOR ZONTAL BLOCKS OF 41 COL WRTDSK21
START AND END POINTS IN EPTS LINE WRTDSK22
               ILINE
                NHOR
                IPSTR. IPEND
                                     THE BAND CESTRED, SET=5 FOR ALL FOUR WRTDSK23
                NBAND
                                                                              WRTDSKZL
                                                                               WRTDSKES
                                                                               WRTDSK26
       SUBROUTINE WRIDSK (ILINE, NHOR, IPSTR, IPEND, NBAND)
                                                                               WRTDSK27
                                                                               WRTDSK28
       D_MENSION ILINE(1)
                                                                               WRTDSK2"
                                     IF ALL BANDS, SKIP DOWN
                                                                               WRTDSK3[
 C
       IF (NBAND.EQ.5) GO TO 100
                                                                               WRTDSK3:
                                      WRITE ONE BAND ONLY
                                                                               WRTCSK31
 C
       NDSK=10+NBAND
                                                                               WRTDSK3
                                      WRITE NHOR BLOCKS
                                                                               WRTGSK31
        DO 10 J=1 . NHOR
                                                                               WRTDSK3!
        IPSTRT=(J-1) #41#4+NBAND+IPSTR
                                                                               WRTDSK3
        IPSTOP=IPSTRT+40*4
                                                                               WRTOSK31
        WRITE(MOSK) (ILINE(IP), P=IPSTRT, IPSTOP, 4)
                                                                               WRTGSK3
        CONTINUE
                                                                               WRTUSK3'
 10
        RETURN
                                                                               WRTUSK4
        CONTINUE
                                                                               WRTDSK4
 100
                                      WRITE ALL FOUR BANDS
                                                                               WRTDSK4
 C
        DO 101 I=1.4
                                                                               WRTESK4
        NOSK=10+I
                                                                               WRITESK4
                                      WRITE NHOR BLOCKS
                                                                                WRTDSK4
        00 101 J=1,NHOR
                                                                                WRITESK4
        IPSTRT=(J-1)*41*4+I+IPSTR
                                                                                WRTESK4
        IPSTOP=IPSTRT+40*4
                                                                                WRTDSK4
        WRITE (NOSK) (ILINE (IP) , IP=IPSTRT, IPSTOP, 4)
                                                                                WRTSSK4
                                                                                WRTESK5
        CONTINUE
  101
        RETURN
                                                                                WRTCSKS
        END
```

		RDGSK17
VERSION IL WRITTE	JAN 1974	RODSK10
VERSION II WILLIE		RDCSK10
DESCRIPTION OF PR	1GRAM.	RUDSK10
MATTIO CHIS STAT	F DEADS THE ERTS DATA FROM THE DISC FILES AND	GDDSK10
THEN PRIMITS OUT A	PROTURE OF THE DATA, PROJETUING VENILUALLY AND	RODSK10
THEN FRINIS OUT A	RIGHT. SINCE THE BLOOKS ARE 41 CO.S THEN THO	RODSK10
THEN FROM LETT TO	AGE. EL MINATING ONE HALF OF THE TOTAL LINES.	<b>RDDSK10</b>
MILL PIT ON ONE P		RODSK11
INTERNAL PARAMETE		R005K11
NGL	NUMBER OF GREY LEVELS IN IMAGE	RDDSK11
NGL NG	NUMBER OF QUANTIZING LEVELS	RUDSK11
IASIZE	SIZE OF ARRAY TO BE QUANTIZED	RDDSK11
——————————————————————————————————————	HALF OF NHOR	RDDSK11
MHOR	NUMBER OF COLUMNS USED IN IMAGE	RDDSK11
NCOL	NUMBER OF RECORDS TO SKIP TO STAY IN	R005K11
NSKIP	THE SAME STRIP	RODSK11
- [ - [ - 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	TRUE INDICATES THE LAST STRIP	<b>RDDSK1</b>
LAST	IKOE INDICATES THE ENST STORY	RODSK1
		RUUSK1
FNTRY POINT.	AND MICOT MOCK	RODSK1
	K1 (IMAGE, QUAN, NHOR, NVERT, NDSK)	RDDSK1
INPUT ARGUMENTS.	100 to 0100 THO 44 V 44 2 3000	RDCSK1
IMAGE	ARRAY TO STORE TWO 41 X 41.3_JCKS	RODSK1
QUAN	TRUE FOR EQUAL PROBABILITY QUANTI-	RUDSK1
	ZATION OF THE IMAGE	RÜDSK1
MAX	MAXIMUM GREY TONE IN IMAGE	RJDSK1
MLN	MINIMUM GPEY TONE IN IMAGE	
NHOR	HUMBER OF HORIZONTAL BLOCKS	RDDSK1
NVERT	NUMBER OF VERTICAL BLOCKS	RDDSK1
NDSK	FILE CODE OF DISC TO BE PRODESSED	ROCSK1
	소생님 이 되어 가는 몸이 가고 들은 이를 눈을 통해를 살아갈수요?	RDCSK1
area (a 🎖 a taga taga taga taga taga taga taga t	그 어느 그는 돈 살이 일삼는 아니지는데 그림을 내 놀래보는 하나는 말이었다.	RUDSK1
	그 그는 그렇지요. 해가 되는 맛있는 것이 되는 사람이 되는 사람들이 다른 사람들이 되었다.	RODSK1
CHARACHTINE RODSK	(IMAGE,QUAN,NHOR,NVERT,NDSK)	RODSK1
300,20072,102	[17] [18] [4] 살아보고 하고 있는 것은 하고 말라고 먹고 있다.	RDDSK1
D. MENSION IMAGE	나 , 62 ) 그 사람들은 사람들은 사람들은 사람들이 함께 보고 있는데 그렇게 다 하다.	RODSK1
LOGICAL EOF QUAN	[[AST   1 ] [1 ] 등 [기가 기가 기가 기가 되고 있다.] 함께 모든데 [	RDDSK1
EOF=.FA_SE.	경기에 따라 보는 것이 되는 것은 사람들이 되었다.	RDDSK1
LAST= .FALSE.	기민주는 말하지만 이 느라들다 하는데 이 그로 모든 거리에 살아가 된 그를 했다.	RODSKI
LASI= * FALTE *		ROOSKI
CALL FLEEDF UNDSK	DETERMINE THE NUMBER OF LEVELS	RDDSK1
	가는 사람들이 있는 것이 되었다. 그는 사람들이 가장 하시는 사람들이 가장 되었다. 그는 사람들이 가장 되었다. 그는 것이 되었다. 그 사람들이 모르는 것이 되었다. 그는 사람들이 가장 있는 것이 되었다. 사람들이 가장 되었다. 그는 것이 되었다. 그는 사람들이 가장 되었다. 그는 것이 되었다. 사람들이 가장 되었다. 그는 것이 되었다.	RODSK1
MAX=63	그 내용 얼마를 하는데 가게 하는데 가지 않는데 그는 사람들이 가지 않는데 되었다.	RODSK1
MIN=0	그 사람들은 아니라 사람들은 하고 하는데 얼마를 보는데 하고 있다. 그는데 모든 나쁜 바다	RODSKI
IF (QUAN) MAX=11	SET UP FOR QUANTIZATION	RDDSK1
물리가는 물리가 하는 말을 가지하였다.		RDDSK1
NGL=75	化复合物 医动物 医感染 医无足虫 医毛毛囊 医多色素 医多种毒素的 经数 医阴道的 阿尔克克 医皮克勒氏结样	RDDSK1
ND 6-4-2	그는 사람들은 이 아니는 그들은 그들은 사람들이 가장 그리고 있다면 하는데 그들은 사람들이 되었다. 그들은 그는 그들은 그는 그를 살아 보고 있다면 하는데 하는데 되었다. 그 이 사람들이 되었다.	
- 1 E	EPRODUCIBILITY OF THE	RODSK1

#### READ DISC AND OUTPUT PIGTURE

	and the second of the second o		RODSK151
	IF (NHOP.NE.1) GO TO 2		RDDSK152
2_			RODSK153
3	NCOL=41		RODSK154
	MH09=1		RDDSK155
S	IASIZE=41*NCOL SE	T THE NUMBER OF RECORDS TO SKIP	
C		TO REMAIN IN THE SAME STRIP	RODSK156
C	NSKIP=NHOP-(NCOL/41)		RODSK15
	NSKIP=NHOD- (NCOL) 411	O THRU HORIZONTALLY	
C	to the control of the		ROCSK15c ROOSK16L
	00 100 J=1,MHOR		
	REWIND NDSK		RODSK161
	K=J TF(LAST) K=(NHOR/2)+1	는 희망는 하는 용명하면 하는 사람이 살고를 하는 <u>요요. 그</u> 리고 있다.	RDDSK162
	IF (LAST) K= (NH)R/2)+1	F FIRST BLOCK, DO NOT SKIP OVER	RODSK164
C			
	IF (K. EQ. 1) GO TO 5		RODSK165
	DO 1 I=2,K IF(NHOR.GT.1) READ(NDSK)		RDDSK16F RDDSK167
	TE (NHUK . G I . I ) KCAD (10 )		
1	READ(NOSK)	F ONLY ONE BLOCK VERTICALLY. DO NOT	RODSK16
C		NITIALIZE SNAP IN PITCHR	ADE 3WEG
C			RDCSK17
5	IF (NVERT. NE.1)	NCOL, NVERT,, MAX, MIN.,,,,,1.21,,)	RODSK171
	T CALL PITCHE (IMAGE) 411	READ IN THO 41 BY 41 BLOCKS	ROCSK17
C		[TILL 17] - 아노보는 네트로 아이는 스티트 이렇게 다 보다.	RDDSK17:
	00 50 II=1.NVERT	READ 41 ROWS	RODSK17'
C			RDDSK17
	00 20 JJ=1,41	READ NOOL COLUMNS	R005K17
C		ot - 4 : // 1 1	8005K17
	READ(NCSK) (IMAGE(JJ;KOL);KI IF(NCOL.EQ.82) READ(NDSK) (	IMAGE (JJ, KOL), KOL=42,82)	RODSK17
	The MODE & Elfe os	SKIP OVER RECORDS NOT WANTED	RDDSK18
C	IF (NSKIP . FQ . 0) 50 TO 20	병선 가는 이 그리고 얼마를 보고 있다면 하는 것 같아?	RDDSK18
	00 16 N=1,NSVIP	하는 경상 등의 어느 하는 사람들은 하는 그는 그는 그는 그를 가는 것이다.	RDDSK18
	READ (NOSK)	실기한 시간이 아니라 그렇게 그리네요? 사람들 물고먹을 어	RDCSK18
	IF(FOF) GO TO 20	프랑스 아이 이 아이들는데 같은 만든만의 얼룩되다.	RDDSK13
		2122의 그 그 그 그 그 이 그 이 일 한 사람이 되는 것을 모래 되다.	RDDSK18
16	CONTINUE		ROCSK18
50		기가 되는 말이 되었습니다. 그 이 아버트를 바라 되었다.	RDDSK18
		QUANTIZE THE IMAGE	RDUSK18
C	IF (QUAN) CALL KEQUAN (IMAGE)	NGL,NQ, LASIZE)	RJDSK18
		SNAP OUT A 41 BY 82 BLOCK	RODSK19
C			
	IF (NVERT.EQ.1) CALL PITCHR!	(IMAGE, 41 . NCO_ , 1 . , MAX , MIN , , , , , , 1 . 21 , ,	RODSK19
	CONTINUE		RDDSK19
50	CONTINUE	and the first of the contract	2005K19
100		CHECK TO SEE IF NHOR IS EVEN	RDDSK19
C	IF (NHOR.EQ.1) GO TO 101	경험을 하는 이름을 하면 오십 때를 일어 없는 살아면 살아면 하다 했다.	RDDSK19
	IF (NHOR.EQ. (MHOR*2)) GO TO	101	
		IF NOT. DO THE LAST STRIP OF 41 COLS	RUDSK19
C	IF (LAST) GO TO 101	할을 하는 경험을 들어 못한 살았다. 하는 하는 말은 당상하는 것은 때문	RODSK19
	LAST=.TRUE.	아마리 아마리 사람들이 아마리 아니라 아마리 아마리 아마니다.	RODSK10
	GO TO 3	[발표] : : : : : [ [ ] . [ ] . [ ] . [ ] . [ ] . [ ] . [ ] . [ ] . [ ] . [ ] . [ ] . [ ] . [ ] . [ ] . [ ] . [ ]	
and the state of the state of	소면 요즘 주민들이 되지 않는 경험을 모습이다. 이는 이 사람들이 나는 그 사이 가지 않는데 되었다.	1、1、1、1、1、1、1、1、1、1、1、1、1、1、1、1、1、1、1、	

02-12-74 19-078

# READ DASC AND OUTPUT PICTURE

G.	WRITE THE BAND NUMBER	- <b>RUUSKI</b> ( - ROUSKIC
101	IBAND=NOSK-10	RJOSK10
	WRITE(6,102) IPANO FORMAT(6X,*PICTURE FROM BANC NUMBER*(12)	RODSK1L
102		RODSKIT
	PRETURN CONTROL OF THE CONTROL OF TH	RODSKIF
product and the con-		

Avroll.	<b>A.1</b>	K-E-Q-U-A-N	KEGUANO1
CKEQU	AN .		KEGUANDS
Ç	WRITTEN BY G. ELLIO	T SEPT 1971	KEQUAN03
C	VERSION II BY RJ BO	SLEY FOR TASIZE JUNE 1973	KEQUAN04
C	AFK2TOW II BE KO DO		KE QUANOS
C	ACCORDATION OF BROC	D'AM	KEQUANDS
C	DESCRIPTION OF PROG	M WILL QUANTIZE BY EQUAL PROBABILITY THE INPUT	KEQUANDZ
C ·	ADDAY IA TO	NO LEVELS.	KEQUAN 08
C	ARRAT IA FO		KEQUAND9
C			KEQUAN10
C	ENTRY POINT.	LITA NO NO TASTIFI	KEQUAN11
CCC	CALL KEUUAN	((IA, NGL, NG, IASIZE)	KEQUAN12
C			KEQUAN13
C	ARGUMENTS.	INPUT ARRAY TO BE CONVERTED TO	KEQUAN14
C	IA .	QUANTIZED ARRAY	KEQUAN15
CC	en a analy Monte con	NUMBER OF GREY TONE LEVELS IN IA	KEQUAN16
C d	NGL NGL	NUMBER OF QUANTIZING LEVELS	KEQUAN17
C	MQ M	NOWSEK OF GOWALTSTAG FEATTS	KEQUAN18
C	IASIZE	SIZE OF ARRAY IA	KEQUAN19
C			KEQUAN20
•	SUBROUTINF KEQUAN(I	[A,NGL,NQ,LASIZE)	KEQUAN21
C			KEQUAN22
	DIMENSION IA(1), KN	<b>(512)</b> - 1978 - 1975 - 1975 - 1975 - 1976 - 1976 - 1976	KEQUAN23
	IF(NGL.GT.512) WRI	[TE(6,10)	KEQUAN24
10	FORMAT(5X,******	****NUMBER OF GREY LEVELS TOO LARGE*********	KEQUANZS
	00 1 I=1,NGL	선생님 생님들이 그 생각하다 하는 사람이 되는 것이다.	KEQUANZE -
1	KN(I)=0		KEQUAN27
C		COUNT EACH GREY LEVEL	KEQUAN28
	DO 2 I=1, IASIZE		KEQUAN29
	J=IA(I)	하고 하다 있다면 보이 아프로그램이 되는 모아 올라마다 되었다.	
2	KN (J+1) = KN (J+1)+1	용지를 가게 하면 하는 이 생각을 하고 있다. 그 이 경찰 이 동일 하는	KEQUAN30
	NP=1ASIZE	이어 사람들의 어린이 보다 하는 그리는 것 같아 있다. 그는 모양하다	KEQUAN31
	J=1		KEQUAN32
	MQ=NQ	회의 이의 목표를 들었다. 하는 사이들은 사는 사람들은 아이를 만들었습니?	KEQUAN33
C		GO THRU NO LEVELS	KEQUAN34
	DO 3 I=1.NQ	물로 많아 들었는데 하시네 이 등을 모임을 하시네요? 다양하다	KEQUAN35
	N_ =NP	다 안의 네트로 되어서는 충분했어? 그 회학 차 먹을다. 그는 가 중점이다.	KEQUAN36
C		GET NEW LEVEL	KEQUAN37
4	NL=NL-MQ*KN(J)	교회가를 하고한 없었다는 이 그들은 이미있다는 일반을 가르고 했다.	KEQUAN3P
•	NP=NP-KN(J)	그림과 생물이 되는 사람들은 모든 사람들이 바꾸는 사람들이 모르는 일이 되었다.	KEDUAN3°
	KN (J) = I - 1	그 이번 하다는 사람들은 사람들은 사람들이 되었다. 그리고 있다고 살아갔다.	KEQUAN40
	J=J+1	기가의 그는 맛있는데 그 그는 만든데 이 나는 이 남이 가까지 모음으로만	KEQUAN41
<b>A</b> rasia		CHECK FOR LAST LEVEL	KEQUAN42
C	IF(J.GT.NGL) GO T		KEQUAN43
	1547.01.Week 62 1	INCREMENT AGAIN FOR LEVEL	KEQUAN44
Ç	IF (MQ*KN(J) .LE .NL*	en la comprese de la	KEQUAN45
	Th furthermount.	DECREASE NO. OF LEVELS LEFT	KEQUAN46
<u>c</u>		있으면 얼굴들이는 이렇게 하면요 하기와 데이트링스닷터 회에 하다네셔요요요?	KEQUAN47
3	MQ=MQ-1		KEQUAN48
	DO 5 I=J,NGL	[편문화] 전환 경험 전환 전환 경우 전환 전환 전환 경험 경험 다른	KEQUAN40
5	KN(I)=NQ-1	그 그는 보는 가장 하는 것은 사람들은 그 없어진 않고 못하셨다. 그렇다 살아 하다	KEQUAN5 C
BALAN,	GO TO 8	할 때 비스 보다 남자, 동안 다른 그렇게 들어갔다. 이글 말이 한 경험이 충색이 있었다. 김	
A CARLO SALE A C	ni in terre disconsideri in control de la confittació de la colida.	wana ja nina, wang taung namaya an anang kalaban nina namban an namban katawa an Apada at namban katawa ni antawa ni Sa	and the first of the company of the contract of the con-

•	•	•	SET LAST LEVEL		KEQUANSI KEQUANSI
6	N= (NQ-I)/2			•	KE QUANS 3
	IF (N.LT.1)GO TO	8			KEQUAN54
	DO 7 I=1.NGL				KEQUAN55
. 7 C	Ku(I)=Ku(-)+N		ASSIGN ELEMENTS	TO A LEVEL AND	RETURN KEQUANSE KEQUANST
8	DO 9 I=1, ASIZE J=IA(I)				KEQUAN58 KEQUAN59
9	IA(I)=KN(J+1) RETURN				KEQUAN60 KEQUAN61
	END				

CROOSE	CE READ DISC A	NO LIST GREY TONES	RDDSK201		
C		POSLEY JAN 1974	RDDSK203		
C	VERSION II WRITTEN BY RJ	BUSTEA	RODSK204		
C					
C	DESCRIPTION OF PROGRAM.				
C	THIS SUBROUTINE READS DATA FROM DISC FILE NOSK AND PRINTS OUT THE GREY TONES AND HRITES THEM OUT ONTO AN OUTPUT TAPE.				
C	THE GREY TONES AND WRITE	2 THEW OUT DATE AN ORLEGG THEE	RDDSK208		
C			RDDSK209		
C	INTERNAL PARAMETERS.	BAND BEING PROCESSED	RDDSK210		
C	K	ERTS LINE BEING READ	RDDSK211		
C	LINE	EK12 CINC BEING WEND	RJDSK212		
C			RUDSK213		
C	ENTRY POINT.	E, IRSTRT, IRSTOP, NHOR, NOSK, PRNT, TAPE, IFIL)	9005K214		
C	CALL RUDSKZ (I MA)	E17K21K1117V2101 AMINANA AMINA	RDDSK215		
C			R00SK216		
C	INPUT ARGUMENTS.	ARRAY TO REAU DATA INTO	RDDSK217		
C	IMAGE TOSTOR	STARTING, STOPING LINES OF DATA	RDDSK218		
Ç	IRSTRT, IRSTOP	STARTING STORES	RODSK219		
Ç		NUMBER OF HORIZONTAL BLOCKS	SDDSK230		
Ç	NHOR	FILE CODE OF DISC WITH DATA	ROCSK221		
C	NOSK	TRUE FOR GREY-TONE LISTING	ROCSK222		
C	PPNT	TRUE FOR TAPE OUTPUT	RDDSK223		
C	TAPE	OUTPUT TAPE FILE CODE	ROOSK224		
Ç	IFIL	보는 사람들이 가는 이 가는 사람들이 가지 않는 것 같아. 그렇게 하는 것 같아.	RDSSK225		
C	CURROLITING PROSVALIMAGE.	IRSTRT, IRSTOP, NHOR, NOSK, PRNT, TAPE, IFIL)	RDCSK226		
	208KOOLINE KODZYSTIIINOS		RDDSK227		
C	DIMENSION IMAGE (41,41)	소설이 보고를 하면 하나요 말하는 것 같은 모든 하는 그렇게 되었다.	RDDSK228		
	LOGICAL PRNT, TAPE		RODSK229		
	REWIND NOSK	그렇게 하는 일은 살이 됐다면서 그렇게 되었는 말이 있었다.	RDDSK230		
	K=NDSK-10		RODSK231		
3	V-1102V-10	IF NEITHER TAPE NOR PRINT, RETURN	Q005K232		
~	IF (PRNT) GO TO 2		RDDSK233		
	IF (TAPE) GO TO 3	[2] ^	RDDSK234		
	RETURN		RDDSK235		
C		WRITE HEADING FOR LIST	RDDSK236		
Ž	WRITE(6,1) K	그리는 보다는 일을 내려 보는 것이 살아왔다. 그리는	RDDSK237		
i	FORMATCHIA LINE STRIP	,204, BAND NUMPER IS', 12)	RDDSK238		
Ċ		GO THRU EACH LINE OF DATA	RDDSK239		
3	00 50 LINE=IRSTRT, IRSTO	<b>-</b> 의 시교통방의 여러 - 이 의 - 이 의 공개방송영(원양송) 등 및 및 및 및 및	RSCSK240		
Č		GO THRU EACH BLOCK ACROSS THE IMAGE	RDDSK241		
	DO 50 J=1,NHOR		RDDSK242 RDDSK243		
C		READ ONE LINE	RD05K244		
	READ (NDSK) (IMAGE (1.KO	_),KOL=1,41)	RODSK?45		
C	등 경우를 하다 하는 모든 그리고 모르겠다.	WRITE IT OUT	the second second second		
	IF (PRNT) WRITE (6,100)	LINE, J, (IMAGE (1, KOL), KOL=1,41)	RODSK246 RDDSK247		
	IF (TAPE) WRITE (IFIL)	LINE.J, (IMAGE(1, KOL), KOL=1,41)	RD05K248		
50	CONTINUE	병생님, 생각 보이 다른 계속 내 장면을 보고 보고 그 말을 보고 있다.	R005K249		
100	FORMAT(1X,15,13,4113)	호마, 많이 되는 맛이 하는 것이 없는 것이 되었다. 그렇다 이 문제와	RJDSK250		
	RETURN	맛진하면 하는 하는 아이들은 그는 하고 그렇게 하는 사람들이 나를 하다.	KARSKESO		
	END	그렇게 그리다는 걸었다면서 이 때 하는 사람이 들어 된다고 하다면 하나 살아 있다.			

## IV.2-b Texture Analysis Program Listings

```
MAINLN
ERTS (see IV.2-a)
MAING
KEQUAN (see IV.2-a)
PITCHR (see IV.2-a)
FPLXIT
INDEX
IMOMTR
COR
IEQPQ1
RITOWT
```

```
MAINLNO1
                                                           JUNE 1973
                        ERTS TEXTURE ANALYSIS
CHAINLN
                                                                        MAINLN02
      WRITTEN BY RJ BOSLEY FOR PROCESSING LAWRENCE DATA
                                                           SEPT 1972
                                                                        MAINLNOT
                                                                        MAINLN04
      VERSION 1 BY RJ BOSLEY FOR PROCESSING ERTS DATA
                                                           NOV 1972
                                                                        MAINLN05
                                                           JJNE 1973
      VERSION 2 BY PJ BOSLEY FOR MERGE OPTION
                                                                        MAINLN 06
         *MAIN_N97
                                                                        MAINLNDS
                                                                        MAINLN09
                                                                        MAINLN 10
    PROGRAM IDENTIFICATION.
                                                                        MAINLN11
       PROGRAME TITLE - TEXTURE ANALYSIS
                                                                        MAINLN12
                     - RJ EOSLEY
       WRITTEN SY
                                                                        MAINLN13
       DATE WRITTEN
                     - JUNE 1973
                                                                         MAINLN14
                     - CRINC, UNIV OF KANSAS
       SITE NAME
                                                                         MAINLN15
                     - LAWRENCE, KANSAS
       SITE ADDRESS
                                                                         MAINL 116
                    - 1-913-864-4832
       PHONE NUMBER
                                                                         MAINLN17
                                                                         MAINLN18
    DATE OF MODIFICATION.
                                                                         MAINLN19
                                                                         MAINLN20
       JUNE 1973 -- MODIFIED FOR MERGE OPTION.
                                                                         MAINLN21
                                                                         MAINLNZZ
    HARDWARE / SOFTWARE SUMMARY.
                                                                         MAINLN23
                                                                         MAINLN24
        COMPUTER REQUIRED & HOMNEYWELL 635
                                                                         MAINLN25
                          1
        SYSTEM EXECUTIVE
                            GELOS III
                                                                         MAINLNZE
                           42K
        NEMORY REQUIRED
                                                                         MAINLN27
                          - FORTRAN TV AND GMAP
        PROGRAM LANGUAGE
                                                                         MAINLNER
                          - DNE SURATCH DISK, THO TAPE DRIVES
        PERIPHERALS.
                                                                         MAINLNZO
                                                                         MAINLNED
     PURPOSE .
         THIS TEXTURE ANALYSIS PACKAGE WAS WRITTEN IN ORDER TO
                                                                         MAINLN31
        PROCESS ERTS IMAGERY DATA USING PATTERN RECOGNITION TECHNIQUES.
                                                                         MAINLN32
                                                                         MAINLN37
                                                                         MAINLN34
        SEE "LAND USE CLASSIFICATION", TECH. REPORT NO.2262-1, JANUARY 1973MAINLN35
     METHOD.
                                                                         MAINLN3F
                                                                         MAINLN37
     INPUT.
                                                                          MAINLNSE
                                                                          MAINLN35
       PARAMETER CARDS.
                                                                          MAINLN 40
                            THIS CARD IS USED FOR TITLE INFORMATION
                TITLE CARD.
                                                                          MAINLN41
                         AND IS LISTED ON THE OUTPUT LISTING.
                PARAMETERS ACCORDING TO THE FORTRAN NAMELIST FORMAT
                                                                          MAINLN 47
                                                                          MAINLN 47
                         UNDER THE NAME PARAH, SEE BELOW.
                                                                          MAINLN4
                                                                          MAINLN45
     OTHER INPUT.
                                                                          MAINLN 4E
                                                                          MAINLN47
                     DATA TAPE ON INPUT FILE CODE "ES".
        ERTS IMAGE
                                                                          MAINLN4!
                                                                          MAINLN4'
     ABOPTS.
                                                                        MAINLN5
```

REPRODUCIBILITY OF THE ORIGINAL PAGE IS POOR

0,

```
MAINLN51
  SPECIFIED IN OUTPUT LISTING.
                                                                     MAINLN52
                                                                     MAINLN53
OUTPUT .
                                                                      MAINLN54
  PRINTER OUTPUT.
                                                                      MAINLN55
          PARAMETER VALUES.
                                                                      MAINLN56
           PICTURE OF IMAGE BEING PROCESSED.
                                                                      MAINLN57
           LOORLINATES OF THE IMAGE.
           VALUES OF THE EXTRACTED FEATURES.
                                                                      MAINLN59
           LISTING OF LEX ARRAYS.
                                                                      MAINLN60
                                                                      MAINLN61
   JARD OUTPUT.
       1. COOPDINATES OF THE IMAGE BEING PROCESSED.
                                                                      MAINLN62
                                                                      MAINLN63
           VALUES OF THE FEATURES EXTRACTED.
                                                                      MAINLN64
           LARD COUNT.
       34
                                                                      MAINLY65
                                                                      MAINLNEE
   TAPE OUTPUT.
                                                                      MAINLN67
       1. LOORDINATES OF THE IMAGE DEING PROCESSED.
                                                                      MAINLN68
           VALUES OF THE PEATURES EXTRACTED.
                                                                      MAINLN60
                                                                      MAI NLN7G
RESTRICTIONS.
   1. DATA SET IS STANGARD ERTS DATA TAPE FROM NASA.
                                                                      MAINLN71
       THE NUMBER OF POINTS IN ONE LINE OF THE STRIP BEING
                                                                      MAINLN72
                                                                      MAINLN73
          PROCESSED MUST NOT EX.EED 192 POINTS.
       THE SIZE OF FACH IMAGE MUST NOT EXCEED 4096 POINTS.
                                                                      MAINLN74
   3.
       QUANTIZATION MUST BE 32 LEVELS OR LESS.
   4.
       THE ERTS INPUT TAPE MUST HAVE A FILE CODE .ES.
                                                                      MAINLN76
                                                                      MAINLN77
       IBAND MUST NOT EXCEED FOUR.
                                                                       MAINLN78
                                                                      MAINLN70
SU3PROGRAMS REQUIRED.
                                                                       MAINLNBC
      MAINLN
                                                                       MAINLN81
          ERTS READ PROGRAM
                                                                       MAINLN82
          MAING
                                                                       MAINLNS.
             KERWAN
                                                                       MAINLN84
             PICTUR
                                                                       MAINLN8"
             FPLXIT
                                                                       MAINLNBE
                INCEX
                                                                       MAINLN87
             IMONTS
                                                                       MAINLNBE
                INDEX
                                                                       MAINLNSS
                203
                                                                       MAINLN9[
                IEQPQ1
                                                                       MAINLN9:
             RITOWT
 CARD SETUP FOR SAMPLE RUN.
                                                                       MAINLN94
                                                                       MAINLN9
                     9999 ANYNAME
            TDENT
                                                                       MAI NLN9
            LIBRARY LB
    $
                                                                       MAINLN9
                       M-A-I-N-L-N
            OBJECT
    $
                                                                       MAINLN9
                    ERTS TEXTURE ANALYSIS PROGRAMS ...
                                                                       MAINLN9"
             UKEND
                                                                    . MAINLNO!
            EXECUTE
```

```
MAINLN01
                     LB.R.S.PATTERN/GEE/_IB
                                                                         MAINLNOZ
             PRMFL
                     ES.A100.,99999.,NNAME.INPUT
             TAPE
                                                                         MAINLNOS
                     02,APR.5.
                                                                         MAINLN04
             DSPK
                     32,43K,+238
                                                                         MAINLN 05
             LIMITS
                     IBMF
             INCODE
                                                                         MAINLNOS
             TEST OF TEXTURE ANALYSIS PROGRAMS
                                                   XXXXX
                                                                         MAINLN07
     XXXXX
             N11=1, PNCH=1HN, PICTUR=TSEND
                                                                         MAINLNGS
      SPARAM
                                                                         MAINLNOG
             FNDJOB
      THIS RUN OF THE TEXTURE ANALYSIS PROGRAMS WILL PROCESS THE ERTS MAINLINE
     DATA IN 64 X 64 IMAGES, SIVING ONLY PRINTED OUTPUT, PLUS A
                                                                         MAINLN12
     PICTURE OF THE IMAGES.
                                                                         MAINLN13
                                                                         MAINLN14
                                                                         MAINLN15
  BIBLIOGRAPHY.
                                                                         MAINLN1E
     NASA TECHNICAL REPORT NO. 2262-1. JAN. 1973, "LAND USE
     CLASSIFICATION USING TEXTURE INFORMATION IN ERTS-A MSS IMAGERY*
                                                                         MAINLN17
                                                                         MAINLN15
     BY K. SHANMUGAY, R. HARALLUK, R. BOSLEY.
                                                                         MAINLN1°
  MAINLN2?
     DESCRIPTION OF PROSPAM.
       THIS IS THE MAINLINE OF THE ERTS TEXTURE ANALYSIS PROGRAMS.
                                                                          MAINLN2?
        EACH ERTS IMAGE IS DIVIDED INTO 4 STRIPS, EACH PUT ONTO ONE
                                                                          MAINLNZI
       TAPE. FOR EXAMPLE, IF THE IMAGES ARE 64 X 64. THEN THE FIRST ERTS DATA TAPE CONTAINS SUBIMAGES 1 TO 12, THE SECOND FROM 13
                                                                          MAIN_N2
                                                                          MAINLNEF
                                                                          MAINLN2:
        TO 24, ETC, UP TO 48 HORIZONTAL IMAGES.
          DUE TO CORE LIMITATIONS, EACH INPUT TAPE IS PROCESSED IN
                                                                          MAINLNZ:
        STRIPS WITH EACH STRIP TOTALING UP TO 192 POINTS, HORIZONTALLY, MAINLN2
        IF THE IMAGES ARE 64 X 64, EACH STRIP WILL CONTAIN 3 SUBIMAGES. MAINLN3
        IMAGES WILL RE PROCESSED AS FOLLOWS, RUN1-(1,1),(1,2),(1,3),
                                                                          MAINLN31
        (2,1),(2,2),(2,3),...,(36,1),(33,2),(36,5). RUN 2-(1,4),(1,5), MAINLN3
        (1,6),(2,4),...,(36,4),(36,5),(36,6). ETC.
          NOTE THAT FOR RUN1, N11 IS 1 AND NUMSTR IS 1. FOR RUN 2, N11 MAINLN3
                                   AND FOR THE SECOND TAPE FOR RUN 1,
        IS 4 AND NUMSTR IS 2...
        N11 IS 13 AND NUMSTR IS 1. N11 IS THE UPPER-LEFT COLUMN
                                                                          -MAINLN3
        COORDINATE AND IS PELATIVE TO THE ENTIRE IMAGE, WHERE NUMSTR
                                                                          MAINLN3
                                                                           MAINLN3
        IS THE STRIP NUMBER RELATIVE TO THE DATA TAPE.
           ALSO NOTE THAT THE FIRST 8 POINTS AT THE BEGINNING OF EACH
                                                                           MAINLN3
        LINE ARE LEFT OUT. IT IS POSSIBLE TO HAVE LESS THAN ONE FULL IMAGE AT THE END OF EACH TAPE THAT CANNOT BE PROCESSED.
                                                                           MAINLN4
                                                                           MAINLN4
                                                                           MAINLN4
                                                                           MAINLN4
       DESCRIPTION OF INPUT PARAMETERS UNDER NAMELIST /PARAM/.
                                                                           MAINLN4
                        NO. OF QUANTIZING LEVELS IN TEQPQ1.SET TO 16
                                                                           MAINLN4
C
                        THE NUMBER OF IMAGES TAKEN HORIZONTALLY IN ONE
                                                                           MATRLN4
              NOUANT
C
              NUMIM
                                                                           MAINLN4
CCCC
                                   PASS
                         THE STRIP NUMBER OF THE RUN IN PELATION TO THE
                                                                           MATNLN4
                                                                           MAINLN4
              NUMSTR
                                   ERTS INPUT TAPE
                         THE NUMBER OF IMAGES IN A VERT COL OF THE STRIP MAINLNS
               NOVERT
```

MAINLN51

```
THE NUMBER OF LINES IN EACH NUMLIN X NUMPPL
              NUMLIN
                                                                            MAINLN52
                                   SUB-TMAGE
                                                                            MAINLN53
                        THE NUMBER OF PTS PER LINE IN EACH SUB-INAGE
              NUMPPL
                         ***NOTE***NUMPPL*NUMIM HUST NOT EXCEED 192
                                                                            MAINLN54
                                                                            MAINLN55
                         ***EXAMPLE***IF NUMPPL=64. THEN NUMIN=3
                                                                            MAINLN56
                         ***FXAMPLE***IF NUMPPL=32.THEN NUMIM=5
                                                                            MATNLN57
                         THE SPECTRUM BAND TO BE PROCESSED FROM 1 TO 4
              IPAND
                                                                            MAINLN58
                         SPECIFIES THE OUTPUT OPTION---Y FOR CARDS, T
              PNCH
                                   FOR TAPE, AND N FOR PRINTER ONLY
                                                                            MAINLH59
                         ***NOTE***PNCH MUST BE DENOTED AS A HOLLERITH
                                                                            MAINLNSO
                                   CONSTANT IN THE DATA CARD
                                                                            MAINLN61
                                                                            MAINLNES
                         THE UPPER LEFT COLUMN COORDINATE FOR THE STRIP
              N11
                                                                            MAINLN63
                                    BEING PROCESSED
                         THE FILE CODE OF THE OUTPUT TAPE--ASSUMED TO BE MAINLN64
              IF
                                   IN POSITION
                                                                            MAIN_N65
                         THE NUMBER OF VERTICAL ROWS OF SUB- MAGES TO
                                                                            MAINLNEE
              NESKIP
                                                                            MAIN_N57
                                    9E SKIPPED PRIOR TO EXECUTION
                         IF TRUE., THE LEX ARRAYS WILL BE MERGED TO ONE MAINLNES
              MERGE
                         IF .TRUE., A PICTURE OF EACH SUBINAGE WILL BE ..
                                                                            MAINLN69
              PICTUR
                                                                            MAINLN70
                                   PRINTED
                         ***NOTE***PROCESSING IS. APPROXIMATELY --
                                                                            MAINLN71
                                    100 PERCENT = MERGE-OFF, PICTUR-ON
                                                                            MAINLN72
                                                                            MAINLN73
                                    125 PERCENT = MERGE-ON , PICTUR-ON
                                    158 PERCENT= MERGE-ON , PIGTUR-OFF
                                                                            MAINLN74
                                                                            MAINLN 75
                                                                            MAIN.N76.
                                                                             MAINLN77
     D_MENSION ILINE(4096), TITLE(14)
                                                                             MAINLN78
     COMMON /Q/ NQUANT
      COMMON M1.N1.F(15), IMAX, IMIN, NUMPPL, NUMLIN, NBUBL, IR1, IR2, IR3, IR4,
                                                                            MAINLN79
     1 DUMMY(29), LEAST1, NRED, NLAYER, NSTART, NTIMES, NO, PNCH
                                                                             MAINLNSO
                                                                             MAINLN81
      JOMMON /EC/ENTROP(4), DIFENT(4), DIFAVE(4), DIFVAR(4), SUMENT(4),
                                                                             MAINLNSZ
     1SUMAVE (4) . SUMVAR (4)
                                                                             MAINLNBE
      COMMON /CORREL/CORINF(4), CORMUT(4), CORMAX(4)
                                                                             MAINLN84
      COMMON IMAGE (64,192)
                                                                             MAINLN85
      LOGICAL MERGE, PICTUR
      NAMELIST/PARAM/NUMIM, NUMSTR, NEVERT, IBAND, N11, MERGE, PICTUR, NESKIP, MAINLNAG
     1 PNCH, NUMPPE, NUMLIN, NPED, NLAYER, NSTART, NTIMES, NGUANT, IF
                                                                             MAINLN37
      WATA BAND NUMIM NEVERT NESKIP MERGE, PICTUR, N11/2, 3, 36, 0, TRUE.
                                                                             MAINLN88
                                                                             MATNINS9
     1 .FALSE., 1/, TAPE/1HT/, NUMSTR/1/, IF/03/, Y/1HY/, N/1HN/
                                                                             MAINLN90
      PNCH=TAPE
                                                                             MAINLN91
      NUMPPL=64
                                                                             MAINLN92
      NUMLIN=64
                                                                             MAINLN93
      NPED=1
                                                                             MAINLN94
      NLAYER=1
                                                                             MAINLN95
      NSTART=1
                                                                             MAINLN96
      NTIMES=1
                                                                             MAINLN97
      NOUANT=16
                                                                             MAINLN98
               ***SECTION I--PREPARE FOR ERTS READING AND PROCESSING*****MAINLN99
Č
                                                                             MAINLNOO
```

		MAINLN01	
C	The same two water at our control of the same and the same at the	MAINLNDS	
C	READ TITLE AND WRITE IT OUT	MAINLN03	
C		MAINLN04	
	READ(5,6) (TITLE(I),I=1,14)	MAIN_NOS	
	WRITE(6.21) The green of the state of th	MAINLN 06	
/	WRITE(6,7)(TITLF(I), I=1,14)	MAINLN 07	
21	FORMATI //////40 X. ERTS TEXTURE ANALYSIS ////)	MAINLNOR	
<b>∥</b> 6	[ FORMAT (13A6, A2) ]	MAINLNOS	
.7	FORMAT(20X,13A6,A2///)	MAINLN10	
S	보는 병원들이 보는 사람들은 사람들이 없는 것이 있다. 그는 그 사람들이 살아 가는 사람들이 없다.	MAINLN11	
C	READ ERTS TEXTURE PARAMETERS	MAINLN12	
C	어느 어린 그 사람들은 그리는 아들은 바꾸는 마음을 하고 있다면 그 모습니다. 이 회에 아침에 하는 그 모습니까 해야 된다.	MAINLN13	
· 5	COREAD (5, PAPAM)	MAINLN14	
	N=NUMIM*NUMPPL	MAINLN14	
	IF (M.LE.192) GO TO 2		
	100000000000000000000000000000000000000	MAINLN16	
1	FORMAT( NUMBER OF IMAGES TIMES THE NUMBER OF POINTS IN EACH LINE	MAINLNII	
. · · · · · · · · · · · · · · · · · · ·	1MUST NOT EXCEED 192 ')	CHARLINE ATO.	
		MAINLN19	
C	그 경기에 가는 사람들이 가는 사람들이 가는 사람들이 가장 가장 하는 것은 것은 사람들이 되었다. 그런 것	MAINLN20	
Č	INITIALIZE THE ERTS READ PROGRAM AND WRITE OUT PARAMETERS	MAINLN21	
Č	그는 하시다 하시트로 하시다. 하시다 하시다 그 그 그 그 그는 그는 그는 그는 그는 그를 가는 그를 가는 그는 그를 가는 그는 그를 가는 것이다.	WAINTNSS	
2	CALL EINIT (LENGTH)	MAINLN23	
Ċ	はずにいまっては、ことにはない。ということとなることがです。 かんばい こくしゅ しゅうほんにんき	MAINLN24	
· ·	WRITE(6.11) LENGTH, NUMIM, NUMSTR, NBVERT, IBAND, NBSKIP	MAINLN25	
	WRITE (6, 101) PNSH, NUMPPL, NUMLIN, NRED, NSTART, NTIMES, NQUAND	MAINLN26	
11	CORMATALOV ILENGTH OF EDTS THE TS	MAINLN27	
1 1	TE A DOTATE MARY EMINISED OF HORTZONTAL IMAGES NUMING 45 1441/	MAINLNZ8	
	PART THIS STOTE TO MIMBER ".TO./INX. NUMBER OF VERTICAL IMAGES OF	AUM THE AS	
		HATHEHOU	
	AANU REUTEDEN NOUM * TR. * VERTTCA: IMAGES BEFORE STARTENS ////	INTIATIOT	
101	FORMAT (10 X, PUNCH= . A3, NUMPP_= . 14, NUMLIN= . 14, NUMLIN= . 14, NRED= . 13,	MAINLN32	
	1. NSTAPT= .13. NTIMES= .13. NQUANT= .14)	MATHEMAS	
	THEOREM UNITEEL 71	MAINLN34	
3	FORMAT (//10X, THE FOUR LEX ARRAYS HAVE BEEN MERGED INTO ONE ARRAY	MAINLN35	
		THEFT	
	IF(.NOT.PICTUR) WRITF(6.4)	MAINLN37	
	FORMAT( THE PISTURE OPTION IS OFF 1///)	MAINLN38	
4	그림 집 집에 마다 아는 사람들이 그리고 있다. 그리고 있는 사람들은 사람들은 사람들은 사람들은 사람들은 사람들은 사람들은 사람들은	MAINLN39	
C) C	SKIP THE FIRST NBSKIP ROWS OF IMAGES	MAINLN40	
Č	소스 즐겁히는 시간 마리하다 그런 하지만 말을 입물수는 병사 때가 그리고 있습니다. 나는 다른 작업을 받았다.	MAINLN41	
	NOSK=NUMLIN*N3SKIP	MAINLN42	
	CALC ESKIP (NOSK)	MAINLN43	
		MAINLN44	
Č	GO DOWN THE STRIP	MAINLN45	
Ç	IMAGE GOORDINATES (M1,N1) ARE TRANSFERRED IN COMMON	MAINLN46	
Ç	MI GIVES THE ROW JOUNT GOING DOWN THE STRIP	MAINLN47	
Ç		MAINLN48	
C	IPEGIN=((NUMSTR-1)*(192*4))+IBAND	MAINLN49	
	가는 보고 보고 보면 보다 보다 되었다. 그는 사람들은 사람들이 되었다. 그런 그는 사람들이 되었다. 그는 사람들이 되었다. 그는 그를 가는 것이 되었다. 그는 그를 가는 것이 되었다. 그는 그를 살 그렇게 하는 사람들이 보는 사람들이 있는 것이 하는 것이 없는 사람들이 되었다. 그는 사람들이 있는 사람들이 되었다. 그는 사람들이 되었다. 그는 사람들이 모든 사람들이 되었다. 그는 사람들이 모든	MAINLNSO	
C	1200 - 2014년 1일 1일 2014 - 12 14 14 14 14 14 14 14 14 14 14 14 14 14		

_	THE DECLET OF CLOSE POINTS	MAINLN51
C	MOVE THE IMAGE TO THE RIGHT BY EIGHT POINTS	MAINLN52
C		MAINLN53
	IBEGIN=IBEGIN+32	MAINLN54
	JSTOP=IREGIN+((NUMIM*NUMPPL)*4)-IBAND	MAINLN55
	N9=NRSKIP+1	MAINLNSS
4	DO 99 M1=NB,NBVERT	MAINLN57
3	*******SECTION IIREAD ERTS AND MOVE DATA INTO IMAGE******	*MAINLN58
C		TIME THE TOTAL
C	I, INE IS THE ARRAY INTO WHICH THE ERTS DATA IS READ-WILINE AND	MAINLNED
C	TWORK HISE THE SAME STORAGE SPACE	MAINLN61
C	MOONN GIVES THE ROW COUNT IN IMAGE FROM 1 DOWN TO NUMLIN	MAINLNES
Č		MAINLN63
·	DO 90 HOUN-1-NUMLIN	MAINLN64
C	30, 10, 10, 10, 10, 10, 10, 10, 10, 10, 1	MAINLN65
Č	READ ERTS LINE BY LINE	MAINLN65
Č		MAINLN67
	CALL EREAD (ILINE, LN)	MAINLN62
€C ·	and principles of the control of the control of the wife of the control of the co	MAINLNSO
C	INTRETURNED BY EREAD, GLVES THE LINE NUMBER, OR ERROR INDICATION	MAINLN70 MAINLN71
C	이 아이들이 아이는 그 있습니다. 그런 말에 아이들에 하나는 이 아이들이 아니는 아이들이 아이들은 사람들이 하는데 없다.	MAINLN72
	IF (LN.FQ.0) GO TO 996	MAINLN73
C	THE THACE	MAINLN74
C	MOVE EVERY POINT IN THE LINE THAT BELONGS TO IBAND, INTO IMAGE	MAINLN75
C	JSTOP GIVES THE STOPPING POINT IN ILINE FOR THE TRANSFER	MAINLN76
C	THE TRANSFER IS INCREMENTED BY 4. THE NUMBER OF BANDS	MA_NLN77
C	LOUNT GOES FROM 1 TO NUMPPL * NUMEM, GIVING THE LENGTH DOUNT	MAINLN78
C	크리 그는 전 그는 그는 그리고 그 사람들이 되는 그 그리고 있다. 그 물리를 통해 얼굴을 하는 학생들이 되었다.	MAINLN79
	LCOUNT=0	MAINLNSO
A STATE OF	DO 80 IPOINT=IBEGIN.JSTOP.4	MAINLN81
	LCOUNT=_COUNT+1	MAINLN82
	IMAGE (MDOWN, LCOUNT) = ILINE (TPOINT)	MAINLNS?
80	CONTINUE	MAINLN84
90	CONTINUE TO THE REPORT OF THE PROPERTY OF THE	MAINLN 85
C	IMAGE IS FULL. START TEXTURE ANALYSIS	MAINLN86
Č	그는 하고 하는 이 하는데 하는 것이 그 그들이 그 사람은 경험을 가져왔다. 그 없는 이 생생들이 나는 사람들이 하는데 가지 않는데 되었다. 그리는 생각이 되었다.	MAINLN87
Č	*********SECTION IIIPROCESS IMAGE, BLOCK BY 8_OCK********	MAINLN88
Č	a semana kana sebera <del>an m</del> inara na majaja, kataban ang malamban kana ang maja minara Malaman ang malamban kana ma	MAINLN89
Č	BLOCK IMAGE INTO NUMLIN X NUMPPL BLOCKS FOR PROCESSING	MAINLN90
Š	and file and the control of the cont	MAINLN91
	KE=0	MAINLN92 MAINLN93
	DO 60 Jalock=1, NUMIM	MAINLN94
	\$\text{KS=KE+1}	MAINLN95
	KE=KS+NUMPAL-1	MAINL 196
	· (KL=0) - (1대) 젊은 그림은 사람들은 사람들이 가지 않는데 그리고 하는데 말을 때 없다. 하나가 되나 있는	MAINLN97
	DO 59 KLINE=1, NUMLIN	MAINLN98
C	NES OF OVE WITH MOON O VES THE COLUMN COUNT	MAINLN99
C C	KL GOES FROM 1 TO NOR OF PTS WHILE KCOL GIVES THE COLUMN COUNT	MAINLNOO

```
MAINLNO
     DO 59 KOOL=KS+KE
                                                                         MAINLNO
     K_=KL+1
                                                                         MAINLNO
      I_INE(KL) = IMAGE(K_INE + KCOL)
                                                                         MATNENO
      CONTINUE
58
                                                                         MAINLND
59
      CONTINUE
                                                                         MAINLNO
      N1 = (N11-1)+JBLOCK
                                                                          MAINLNO
C
      USE ILINE AS A DUMMY ARRAY TO SEND INORK TO MAING
                                                                          MAINLNO
C
                                                                          MAINLNO
C
                                                                          MAENLN1
      CALL MAING (ILINE, MERR, MERGE, PICTUR, IF)
                                                                          MATHLN1
C
                                                                          MAIN_N1
      CHECK FOR ERROR CONDITION IN MAING
C
                                                                          MAINLNI
                                                                          MAINLN1
      IF (MERR.EQ.1) GO TO 992
                                                                          MAINLN1
      CONTINUE
60
                                                                          MAINLN1
       JONTINUE
99
                                                                          MAINLN1
C
                                                                          MAINLN1
       C
                                                                          MAINLN1
      PUT AN EOF MARK ON OUTPUT FILE IF AND WRITE ANOTHER RESORD
                                                                          MAINLNZ
C
                                                                          MAI NLN2
C
                                                                          MAINLNZ
      ENDFILE IF
                                                                          MAINLN?
      WRITE(IF) (ILINE(K), K=1,10)
                                                                          MAINLN2
      STOP
                                                                          MAINLNZ
C
                                                                          MAINLNS
      ERROR DETECTED --- WRITE FILE MARK AND ANOTHER RECORD
C
                                                                          MAINLN2
C
                                                                          MAINLNZ
      WRITE(6,993) M1.N1
992
      FORMAT(10X, ERROR IN SUBROUTINE MAING, LAST IMAGE HAS ( .. 2, ...
                                                                          MAINLNZ
993
                                                                          MAINLNZ
     112. ') ')
                                                                          MAINLN3
      ENDFILE IF
                                                                          MAINLN3
      WRITE(IF) (ILINE(K),K=1,10)
                                                                          MAINLN3
      STOP
                                                                          MAINLNE
C
                                                                          MAT NLN3
      ERROR DETECTED --- WRITE FILE MARK AND ANOTHER RECORD
C
                                                                          MAINLN3
C
                                                                          MAINLN?
      WRITE(6,997) M1
 996
      FORMAT(10x, UNEXPECTED EOF ON ERTS, LAST ROW COMPLETED WAS .. 13)
                                                                          MAINLN3
 997
                                                                          MAINLN3
       ENDFILE IF
                                                                          MAINLN4
       WRITE(IF) (ILINE(K),K=1,10)
                                                                          MAINLN4
       STOP
                                                                          MAINLN4
       END
```

WRITTEN BY RHH VERSION 1 BY RJ BOSLEY FOR LANRENCE DATA VERSION 2 BY RJ BOSLEY FOR ERTS JATA PROCESSING VERSION 3 BY RJ BOSLEY FOR ERTS JATA PROCESSING VERSION 3 BY RJ BOSLEY FOR MERGE OPTION VERSION 3 BY RJ BOSLEY FOR MERGE OPTION VERSION 3 BY RJ BOSLEY FOR MERGE OPTION  DESCRIPTION OF PPOGRAM.  IHIS SUPROUT. NE PREPARES THE IMAGE IN ARRAY IMORK FOR PITCHR AND THEN PROJESSES IT, ACJORDING TO THE MERGE OPTION, CALL.NJ MAING SUBROUTINES FOR THE LEX ARRAYS. CALCULATING THE TEXTURE FEATURESMAING AND THEN WRITTING OUT THE RESULTS.  MAING AND THEN WRITTING OUT THE RESULTS.  C ENTRY POINT.  C ARGUMENTS.  IHORK THE NUMLIN NUMPP. IMAGE ARRAY MAING	CMAING	ERTS M-A-I-N-G		MAINGO11 MAINGO12
C VERSION 1 BY RJ BOSLEY FOR LANRENCE DATA  VERSION 2 BY RJ BOSLEY FOR ERTS JATA PROCESSING  VERSION 3 BY RJ BOSLEY FOR MERGE OPTION  OPSCRIPTION OF PROGRAM.  C DESCRIPTION OF PROGRAM.  THIS SUPROUTINE PREPARES THE IMAGE IN ARRAY IMPRESED FOR MAING AND THEN PROJESSES IT, ASJORING TO THE YERGE OPTION. CALLINS MAING AND THEN PROJESSES IT, ASJORING TO THE YERGE OPTION. CALLINS MAING AND THEN WRITTING OUT THE RESULTS.  ENTRY POINT.  C ENTRY POINT.  C ARGUMENTS.  I HORK THE NUMLIN NUMPP. IMAGE ARRAY MAING MAI			DATE 02T 1971	MAING093
C VERSION 1 BY RJ BUSLEY FOR ERTS JATA PROCESSING JUNE 1973 MAING VERSION 3 BY RJ BOSLEY FOR MERGE OPTION MAING MAING WERSION 3 BY RJ BOSLEY FOR MERGE OPTION MAING MAIN		WRITTEN BY RMH		MAINGOO4
VERSION 2 BY RJ BOSLEY FOR MERGE OPTION  VERSION 3 BY RJ BOSLEY FOR MERGE OPTION  DESCRIPTION OF PPOGRAM.  THIS SUPROUTINE PREPARES THE IMAGE IN ARRAY IMORK FOR PICHCH MAING AND THEN PRODESSES IT, ACLORDING TO THE MERCE OPTION. CALLING AND THEN WRITTING OUT THE RESULTS.  C AND THEN WRITTING OUT THE RESULTS.  HAING AND THEN WRITTING OUT THE RESULTS.  C ENTRY POINT.  CALL MAING(IMORK, MERR, MERGE, PICTUR, IF)  C MERGE OPTION TO MERGE THE FOUR LEX ARRAYS MAING MAING MERGE OPTION TO MERGE THE FOUR LEX ARRAYS MAING		VERSION 1 BY RJ BOSLEY FOR	LARKEROE DATA	MAINGO 05
C VERSION 3 BY RJ 90SLEY FOR MERGE OPTION  DESCRIPTION OF PROGRAM.  THIS SUPROUTINE PREPARES THE IMAGE IN ARRAY IMORK FOR PITCHR AND THEN PROJESSES IT, ALJORING TO THE MERGE OPTION, CALLING MAING SUBROUTINES FOR THE LEX ARRAYS, CALCULATING THE TEXTURE FEATURESMAING C AND THEN WRITTING OUT THE RESULTS.  ENTRY POINT.  CALL MAING(IMORK, MERR, MERGE, PICTUR, IF)  ARGUMENTS.  I MORK THE NUMLIN NUMPPL IMAGE ARRAY MAING MERRE ERROR FLAG FOR LEX ARRAY SIZE MAING MERRE OPTION TO MERGE THE FOUR LEX ARRAYS MAING MERRE OPTION TO PRINT PLOTURE OF THE IMAGE MERRE OPTION TO PRINT PLOTURE OF THE IMAGE MAING C INTERNAL PARAMETERS.  C INTERNAL PARAMETERS.  NUMHPL HAXIMUM ALCOMABLE SIZE OF THE LEX MAIN MAINUM ARRAYS, NUMPP-NUMLIN NUMPPL HAMING MAINUM GREY TONE LEVEL IN IMAGE MAIN MAINUM ARRAYS, NUMPP-NUMLIN NUMBER OF QUANTIZING EVELS FOR KFQUANMAIN NUMBER OF QUANTIZING EVELS FOR KFQUANMAIN MINIMUM GREY TONE LEVEL IN IMAGE MAIN MINIMUM GREY TONE LEVELS FOR KMAIN MINIMUM GREY TONE LEVEL IN IMAGE MAIN MINIMUM GREY TONE LEVELS IN IMAGE MAIN MINIMU		MEDOTON 2 BY R.I BUSLEY FOR	ERIS DATA PROCESSING	MAINGUO6
DESCRIPTION OF PPOGRAM.  THIS SUPROUTINE PREPARES THE IMAGE IN ARRAY IMORK FOR PITCHR AND THEN PROJESSES IT, ACJORDING TO THE MERGE OPTION, CALLING AND THEN PROJESSES IT, ACJORDING TO THE MERGE OPTION, CALLING AND THEN PROJESSES IT, ACJORDING TO THE MERGE OPTION, CALLING AND THEN PROJESSES IT, ACJORDING TO THE MERGE OPTION, CALLING MAING AND THEN PROJESSES IT, ACJORDING TO THE MERGE OPTION TO THE TEXTURE FEATURESMAING MAING AND THEN WRITTING OUT THE RESULTS.  MAING AND THEN WRITTING OUT THE RESULTS.  MAING COLUMN TO THE NUMBER OF LINES IN THE MAING MAING MERR ERROR FLAG FOR LEX ARRAY SIZE MERGE OPTION TO MERGE THE FOUR LEX ARRAYS MAING MERGE OPTION TO PRINT PLOTURE OF THE MAGE MAING MAIN	,	VERSION 3 BY RJ BOSLEY FOR	WERGE OFITON OSIGE TAND	MAING00/
C DESCRIPTION OF PPOGRAM.  THIS SUPROUTINE PREPARES THE IMAGE IN ARRAY IMORK FOR PIJCHR MAING THIS PROJESSES IT, ACJORDING TO THE MERGE OPTION, CALLING MAING SUBROUTINES FOR THE LEX ARRAYS.CALCULATING THE TEXTURE FEATURESMAING MAING AND THEN WRITTING OUT THE RESULTS.  HAING MAING SUBROUTINE FOR THE LEX ARRAYS.CALCULATING THE TEXTURE FEATURESMAING MAING AND THEN WRITTING OUT THE RESULTS.  HAING MAING MAING SUBROUTINE POINT OF THE LEXT MAING MERGE OPTION TO MERGE THE FOUR LEX ARRAYS MAING MAING MERGE OPTION TO MERGE THE FOUR LEX ARRAYS MAING MAING MERGE OPTION TO MERGE THE FOUR TEXT MAING MAING MAING MERGE OPTION TO MERGE THE FOUR TEXT MAING				MAINGODS
THIS SURROUTINE PREPARES OF THE MASSES IT. A CORDING TO THE MERGE OPTION, CALLING MAINS SUBROUTINES FOR THE LEX ARRAYS CALCULATING THE TEXTURE FEATURESMAING MAING AND THEN WRITING OUT THE RESULTS.  ENTRY POINT.  CALL MAING(IMORK, MERR, MERGE, PICTUR, IF)  ARGUMENTS.  I WORK HERR ERROR FLAG FOR LEX ARRAY SIZE MAINS MERGE OPTION TO MERGE THE FOUR LEX ARRAYS MAINS PICTUR OPTION TO PRINT PICTURE OF THE IMAGE MAING MAING MAING MAING MAING MERGE OPTION TO PRINT PICTURE OF THE IMAGE MAING		DESCRIPTION OF PROGRAM.		MAINGOOG
AND THEN PROCESSES IT. A JORUNU TO THE TEXTURE FEATURESMAING SUBROUTINES FOR THE LEXA ARRAYS.OALCULATING THE TEXTURE FEATURESMAING AND THEN WRITTING OUT THE RESULTS.  ENTRY POINT.  CALL MAING(IHORK, MERR, MERGE, PICTUR, IF)  ARGUMENTS.  IMORK HERR ERROR F.AG FOR LEX ARRAY SIZE MERGE OPTION TO MERGE THE FOUR LEX ARRAYS MAINE OPTION TO PRINT PICTURE OF THE IMAGE MAINE OPTION TO PRINT PICTURE OF THE IMAGE MAINE OFTION TO PRINT PICTURE OF THE IMAGE MAINE OFTION TO PRINT PICTURE OF THE IMAGE MAINE OFTION TO MERGE THE FOUR LEX ARRAYS MAINE OFTION TO PRINT PICTURE OF THE IMAGE MAINE OFTION TO PRINT PICTURE OFTION TO PICTURE OFTI		THIS SUPROUTINE PREPARE		MAINSOID
AND THEN WRITTING OUT THE RESULTS.  AND THEN WRITTING OUT THE RESULTS.  ENTRY POINT.  CAL MAING(IMORK, MERR, MERGE, PICTUR, IF)  ARGUMENTS.  I HORK THE NUMLIN*NUMPP. IMAGE ARRAY MAING MERR ERROR FLAG FOR LEX ARRAY SIZE MAING MERRE OPIION TO MERGE THE FOUR LEX ARRAYS MAING MERRE OPIION TO MERGE THE FOUR LEX ARRAYS MAING MERRE OPIION TO MERGE THE FOUR LEX ARRAYS MAING MERRE OPIION TO MERGE THE FOUR LEX ARRAYS MAING MERRE OPIION TO MERGE THE IMAGE MAING MAING MAING CC INTERNAL PARAMETERS. NUMPP. THE NUMBER OF POINTS PER IMAGE LINE MAING MAXIMUM ALLOWABLE SIZE OF THE LEX MAING MAING MAXIMUM ALLOWABLE SIZE OF THE LEX MAING MAING CC IMAX MAXIMUM GREY TONE LEVELS FOR KFQUANMAIN MINGH MINGHOUSE TOP A ROW OF IMJORK MAING MINGH MINGHER OF GREY TONE LEVEL IN IMJORK MAING CC IMAGE OF GREY TONE LEVEL IN IMJORK MAING CC IMAGE OF GREY TONE LEVELS IN IMJORK MAING MAING CC IMAGE OF GREY TONE LEVELS IN IMJORK MAING MAING CC WERT VERTICAL SCALLE FACTOR FOR PITCHR MAING CC WERT WASHINGTON AND THE TRIANGULA?MAIN MAING CC WERT WASHINGTON AND THE WELLS IN IMAING CC WERT WASHINGTON AND THE WASHINGTON AND	C			MAING011
C AND THEN WRITTING OUT THE RESULTS.  AND THEN WRITTING OUT THE RESULTS.  ENTRY POINT.  CAL MAING(IHORK, MERR, MERGE, PICTUR, IF)  ARGUMENTS.  IHORK THE NUMLIN*NUMPPL IMAGE ARRAY MAING MERR OPTION TO MERGE THE POUR LEXA RRAYS MAING MERGE OPTION TO MERGE THE POUR LEXA RRAYS MAING MERGE OPTION TO PRINT PICTURE OF THE IMAGE MAING M		SUBROUTINES FOR THE LEX	ARRATS CALCULATING THE CANON	MAING012
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C L1L6 ADDRESS INDEXS FOR THE LEX ARRAYS MAIN C MAIN C MAIN C MAIN C MAIN C SUBROUTINE MAING (IWORK, MERR, MERGE, PICTUR, IF) MAIN MAIN	ř	NBUBL	THE NUMBER OF LEVELS IN THE INTANGOLO	MATHG04
C MAIN C SUBROUTINE MAING (IWORK, MERR, MERGE, PICTUR, IF) MAIN MAIN	Č	보이는 시간 그들은 얼마 얼마를 하는 사람이다.	LEX APRAY	MAING 04
C MAIN C MAIN C MAIN C MAIN C MAIN C MAIN C SUBROUTINE MAING (IWORK, MERR, MERGE, PICTUR, IF)  MAIN MAIN			ADDRESS INDEXS FOR THE LEX BEATTS	MAING04
C MAIN C MAIN C SUBROUTINE MAING (IWORK, MERR, MERGE, PICTUR, IF)  MAIN MAIN MAIN			이 없는데 그 그리는 생각이 되는데 그리는데 젊을 모양을 잃었다면요	MAING04
C MAIN C SUBROUTINE MAING (IWORK, MERR, MERGE, PICTUR, IF) MAIN MAIN				MAING04
SUBROUTINE MAINS (IWORK, MERR, MERGET TO ONLY)	C		를 경기 귀를 잃는데, 그 말겠고 말했을 것같고 한다는 경약없다.	MAING 041
SUBROUTINE MAINS (IWORK, MERR, MERGET TO ONLY)	Č	원회 공급 등의 교회를 돌아가게 되지 않는		MAING04
역 . 마다는 이 보고 있는 것 같아. 그는 사람들은 사람들은 사람들이 되었습니다. 그는 사람들은 사람들은 사람들은 사람들은 사람들은 사람들은 사람들은 사람들은		SUBROUTINE MAING (IWORK, ME		MAING04
A 1. \$ B. \$ B. B. C.	C		그들이 항공 방문 없는 것을 하셨다. 통하고 얼마를 받아 들어올라고 있다.	MAINGO4
사고 하는 사람이 본 전투 회복 전혀 가득 한 경찰 경찰 중점 경찰 경찰 기계 기상 기상 기상 기상 기상 기상 기상 기업 전 기업 기업 기상 기상 기상 기업		LOGICAL MERGE PLCTUR	이번 문문 보고 돌아내지 사람들은 내내려가 되었는데 하는 다른 살이 되었다. 맛요	MAING05
DIMENSION IWORK(4096)	er egy fullul gyf. Y gall den agal i dêl	DIMENSION IMORK(4039)	교통에 가르고 이 15분 전 하고 2016년 전 1일 교통 등 선생님들은 그 10분 교통으로 이 10분 하는 모든 이 15분 이 1일 하는 수 있다. 그는 10분이 즐겁는 교회가 되었는데 교통하는 그 기업을 통해 교통을 선생들은 전상을 받아 하는 것은 모든 그 있는 것이 되는 것을 받아 보는 것이 되었다.	

```
MAING051
     DIMENSION G(64), IQ(64)
                                                                            MAING052
     COMMON M1,N1,F(15), IMAX, IMIN, NUMPPL, NUMLIN, NBUBL, IR1, R2, R3, IR4, MAINGO53
    1 DUMMY (29) , LEAST1 , NEED , N_AYER , NSTART , NTIMES , NJ , PNC4
                                                                            MAING055
     COMMON /ET/ENTROP(4) DIFENT(4) DEFAVE(4) JIFVAR(4) SUMENT(4) .
                                                                             MATNG056
    1SUMAVE (4) . SUMVAR (4)
                                                                             MAING057
     COMMON /CORREL/CORINF (4), CORMUT(4), CORMAX(4)
                                                                             MAING058
      COMMON INAGE (64,192)
                                                                             MAING059
      NIJMUN#J99MUN=MICN
                                                                             MAING 060
                                                                             MAING061
      NQ=32
       REWIND SCRATCH FILE, COPY THAGE IN A LINE BY LINE FASHION ONTO
                                                                             MAING062
       THE SCRATCH FILE, AND DETERMINE THE MINIMUM AND MAXIMUM GREY TONEMAINGOSS
C
                                                                             MAING 065
C
                                                                             MAINGOSF
      REWIND 2
       FIRST, QUANTIZE THE ARRAY TO NQ LEVELS FOR PIJTURE AND EFFICIENCYMAINGO 67
C
                                                                             MAING069
C
                                                                             MAING070
      IMAX=-10000
      IMIN=10000
                                                                              MAING071
      DO 13 J=1.NUMLIN
                                                                             MAING072
      IS=NUMPPL*(J-1)+1
                                                                              MAINGUTE
      IE=NUMPPL*J
                                                                              MAING07
      DO 12 K=IS,IE
                                                                              MAING07F
      IF (IMIN.GT.IWORK(K)) IMIN=IWORK(K)
                                                                              MAING076
      IF (IMAX.LT.IWORK(K)), IMAX=IWORK(K)
                                                                              MAING077
   12 CONTINUE
                                                                              MAING07
                                                                              MAINGO7
   13 CONTINUE
                                                                              MAINGOS
      NGL=IMAX+1
       IASIZE=NUMPPL#NUMLIN
                                                                              MAING 081
       CALL KEQUAN(IWORK; NGL, NQ, IASTZE)
                                                                              MAING03
                                                                              MAINGOS.
C
        COPY IMAGE ON SCRATCH FILE AFTER QUANTIZATION
                                                                              MAINGO 8
C
                                                                              MAINGO 8'
       DO 20 I=1.NUMLIN
                                                                              MAINGO 3
       IS=NUMPPL*(I-1)+1
                                                                              MAINGO 8
                                                                              MAING08
       IF=NUMPPL*I
                 (IWORK(K),K=IS,IE)
                                                                              MAINGO8
       WRITE(2)
       CONTINUE
                                                                              MAING09
 20
        THE MAXIMUM AFTER KEQUAN QUANTIZES TO NO LEVELS IS NO-1, MINIMUM=0 MAING09
 C
                                                                               MAING09
 C
                                                                              MAING09
 C
                                                                               MAING09
       IMAX=NQ-1
                                                                               MAING09
       1MIN=0
                                                                               MAINS09
        JEST FOR PICTURE OPTION
                                                                               MAINGOO
                                                                               MAING09
 C
        IF (.NOT.P.CTUR) GO TO 16
                                                                               MAING09
                                                                               MAING10
 C
        TRANSPOSE INORK FOR PITCHR
                                     REPRODUCIBILITY OF THE
```

ORIGINAL PAGE IS POOR

```
MAINS101
                                                                             MAING102
C
      L=0
                                                                             NAING173
      DO 14 I=1.NUMLIN
                                                                             MAING184
      L=L+1
                                                                             MAING105
      IS=NUMPPL*(I-1)+1
                                                                             MAING106
      IE=NUMPPL FI
                                                                             MAING107
      K = 0
                                                                              MAING108
      00 15 J=IS+IE
                                                                              MAING109
      K=K+1
                                                                              MAING110
      IMAGE(L,K)=IWORK(J)
                                                                              MAING111
   15 CONTINUE
                                                                              MAING112
      CONTINUE
14
                                                                              MAING113
                                                                              MAING114
       PRINT OUT PICTURE OF THE IMAGE
                                                                              MAING115
                                                                              MAING116
      HORZ=(64.0*0.90)/FLOAT(NUMPPL)
                                                                              MAING117
       VERT= (64.0*0.75) /FLOAT (COMLIN)
       CALL PITCHR (IMAGE, NUMLIN, NUMPPL, 0, 1, 0, IMAX, , 0, , , , HORZ, VERT, )
                                                                              MAING118
                                                                              MAING119
       LEAST1=IMIN+1
                                                                              MAING120
16
                                                                              MAING121
        NOBL IS THE NUMBER OF BRIGHTENESS LEVELS
                                                                              MAING122
                                                                              MAING123
C
       NOBL=IMAX-LEAST1
                                                                              MAING124
        NBUBL IS THE NUMBER OF LEVELS IN THE TRIANGULAR LEX ARRAY
                                                                              MAING125
೦
                                                                              MAING125
C
                                                                              MAING127
       NBUBL=NOBL + (NO3L+1)/2
                                                                              MAING128
                                                                              MAING129
 C
        SET UP THE INDEXS FOR THE LEX ARRAYS
                                                                              MAING130
 C
                                                                              MAING131
       L1=1
                                                                              MAING132
       L2=L1+NUMPPL#2
                                                                              MAING133
       L3=L2+N9U3L
                                                                               MAING134
       L4=L3+N3U6L
                                                                               MAING135
       L5=L4+NBUGL
                                                                               MAING136
       L6=L5+NBUPL-1
                                                                               MAING137
                                                                             MAING138
 C
        CHECK THE SIZE
 C
                                                                               MAING139
                                                                               MAING140
        IF (L6.GT.NDIM) GO TO 78
                                                                               MA ING1 41
        DO 4 NN=NSTART + NTIMES
                                                                               MAING142
        REWIND 2
                                                                               MAING143
        NLAYER=NN-1
                                                                               MAING144
                                                                               MAING145
         GET THE LEX ARRAYS
                                                                               MAING14F
        CALL FPLXIT (IMORK(L1), IWORK(L2), IWORK(L3), IWORK(L4), IWORK(L5),
                                                                               MAING147
                                                                               MAING148
       1 NUMPPL MERGE)
                                                                               MAING145
                                                                               MAING 150
 C
         CALCULATE THE TEXTURE FEATURES
```

```
MAING15
C
      CALL IMONTR (IWORK (L2), I WORK (L3), IWORK (L4), IWORK (L5), G, I2, YERGE)
                                                                               MAING15
                                                                               MAING15
C
                                                                               MAING15
       OUTPUT THE TEXTURE DATA
C
                                                                               MAING15
      CALL RITOWT (IWORK(L2), IWORK (L3), IWORK (L4), IWORK(L5), G, I7, MERGE, IF, MAING15
                                                                               MAING15
     1 PICTUP)
                                                                               MAING15
    4 CONTINUE
                                                                               MAING15
C
                                                                               MAING16
       SET ERROR INDICATOR TO NO ERRORS
                                                                               MAING 16
S
                                                                               MAING16
      MERR=0
                                                                               MAING16
      RETURN
                                                                               MAING16
   78 WRITE(6,104) NDIM-L6
                                                                               MAING16
  104 FORMAT (6H NOIM=, 15, 16H NOIM MUST BE = , 17)
                                                                               MAING16
      MERR=1
                                                                               MAING16
      RETURN
                                                                               MAING16
      END
```

O.E.	PLXIT	F-P-L-X-I-T	JUNE 1973	FPLXIT01
= '	PEATI			FPLXITO
C	WRITTEN BY RMH		SEPT 1971	FPLYITO3
C	VERSION 1 BY RJ POSLEY	FOR MERGE	JUNE 1973	FPLXIT04
C	AEKSTON I OF KO TORECT	, , , , , , , , , , , , , , , , , , , ,		FPLXIT95
Č	DESCRIPTION OF PROGRAM			FPLXIT06
C	THE CHOPOLITIME COMPL	ITES FOUR NEAREST	NEIGHBOR GREY TONE MA-	FPLXIT07
C	#01000 1 EV1 . : EV2 . 1	FY3. AND LEX4 FO	ANGLES OF 90-DEGREES.	FPLXITO?
C	0-DEGREES, 135-DEGREE	S. AN. 45-DEGREE	S RESPECTIVELY.	FPLXITO
Ç.	THE BREED THE THE CHAPT	OUTTHE IS AN OPTI	ON TO MERGE THE FOUR LEX	FPLXIT10
C	ARRAYS INTO ONE, LEXI	50/1M2 13 24 0 12		FPLXIT11
C	ARRAYS INTO ONE , LEAT			FPLXIT12
C				FPLXIT13
C				FPLXIT14
C	ENTRY POINT.  CALL FPLXIT(IDATA+	CV4   CV2   CV7.1 F	YA. NUMPPL . MERGE)	FPLXIT15
C	CALE PPEXITATION FACI	CEXTICEX STEEX STEE	V44 1130111 1 6 4 1 2 1 1 2 2 4	FPLXIT16
C				FPLXIT17
C	ARGUMENTS.	HODYTHE 10	RAY FOR TWO LINES OF IMAG	
C	Commission (Control of I DATA	MURKING AR	DEXS FOR LEX ARPAYS	FPLXIT19
Ç.	LEX1-LEX4	AUURESS IN	PTS PER IMAGE LINE	FPLXITZ
Ü,	NUMPPL	NOTION TO	MERSE THE FOUR LEX ARRAYS	FPLXIT21
C	MERGE 1	THIO ON	E ARRAY. LEX1	FPLXIT22
C		THIS ON	C ANNA CALL	FPLXIT23
S				FPLXIT24
С	INTERNAL PARAMETERS.	WWASS OF	LEVELS IN THE TRIANGULAR	FPLXIT2
C	NEUSL	LEX ARR		FPLXIT26
C			FIRST LINE	FPLXIT27
C	IST	POINTER TO	SECOND LINE	FPLXIT28
C	NND	POINTER TO	MAGE REDUCTION	FPLXIT2C
C	NRÉD	BASE FOR 1	TO WHICH NEED IS RAISED	FPLXIT30
C	NLAYER	THE PUWER	REDUCTION OF THE IMAGE	FPLXIT31
C	gill lawn still an <b>mn</b> e god o'r col	AMUUNI OF	LE CONTAINING THE IMAGE	FPLXIT32
C	FILE 2	SURAICH	VALUES OF NEIGHBORING	FPLXIT3?
C	I,J,L,K	GREY ICHE	TION CELLS, ONE TO EACH A	
C	의 동생님을 잃었다고 있는 것인 것이다.	" RESULU	ISEU TO RETURN A SINGLE	FPLXIT3F
C	INDEX(I.J)	FUNCTION	IPT FOR THE LEX ARRAY	FPLXIT36
C		SUBSUR	TING WHERE ELEMENT (I.J)	
C				FPLXIT3
C		BE FOUN		FPLXIT3°
C			- LEVI NUMBOL MEDGEL	FPLXIT40
	SUBROUTINE FPLXIT (IDA	TA, LEXI, LEXZ, LEX	SALEXA MONELLA ME COLA	EPLXIT41
C			141 EVZ141 A EVALAT	FPLXIT42
	DIMENSION IDATA (NUMPA	(L,2), (LEXI(1), (EX	(1) 大大・・・ しこへ 3 1 1 2 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	FPLXIT47
	COMMON MI, NI, TYPE, F (1	41	TOO TOT TON . DIMMY (201	FPLXIT4L
	COMMON I1, I2, NYMPPL	NUMLIN - NOUGE - IKI	, IR2, IR3, IR4, DUMMY (29)	FPLXIT4
in in	COMMON LEAST1 , NRED , N	LAYER, NSTART, NIL		FPLXIT4
	LOGICAL MERGE		아이 말이 남이를 시작한 귀를 만족하는데	FPLXIT47
C		right stable in the first in a fi	4034WC TA TCDA	FPLXIT45
C	INITIALIZE LEX1, LEX	(2, LEX3, AND LEX	AKKATO IU ZEKU	FPLXIT4
C	방향하셨었다. 그 얼마나 그 그렇다는 그 그 그를	병교에 대한 종등 사랑이라 인호생회		FPLXIT50
	DO 10 I = 1, NBUSL	그는 조를 하는 것 같다. 이 작품	사하는 것은 한 없을 가게 없는데 지원 그리스 하나요?	11.544.30

```
FPLXIT51
      LEXI(I) = 0
                                                                         FPLXIT52
      TEXS(I) = 0
                                                                          FPLXIT53
      LFX3(I) = 0
                                                                          FPLXIT54
      LEX4(I) = 0
 10
                                                                          FPLXIT55
                                                                          FPLXIT56
      IR1 = 0
                                                                          FPLXIT57
      IR2 = 0
                                                                          FPLXIT53
      193 = 0
                                                                          FPLXIT59
      IR4 = 0
                                                                          FPLXIT60
                                                                          FPLXIT61
      IST POINTS TO FIRST LINE. NND POINTS TO SECOND LINE
                                                                          FPLXIT62
                                                                          FPLXIT63
      IST = 1
                                                                          FPLXIT64
      NND = ?
                                                                          FPLXIT65
                                                                          FPLXIT66
      NEAVER INDICATES BY HOW MUCH THE IMAGE WILL BE REDUCED.
      NRED IS THE FACTOR BY WHICH THE IMAGE WILL BE REDUCED. (IT IS THEFPLXITS?
      BASE WHICH IS RAISED TO THE POWER NLAYER.) THEN, BY DEFINING THE EPLYITSS
       QUANTITY MM, WHERE MM = NRED**NLAYER, WE HAVE A SINGLE FACTOR
                                                                          FPLXIT69
       THAT DETERMINES THE REDUCTION BASE AND THE AMOUNT OF THE REDUC-
                                                                          EPLXIT70
       ION. IF, FOR EXAMPLE, NRED = 2, AND NLAYER RANGES FROM 0 TO 3 -- FPLXIT71
       THIS RANGE IS DETERMINED BY THE PARAMETER NTIMES (SEE *MAIN*).
                                                                          FPLYIT72
       THE RESULTANT PROCESSING WILL YIELD FOUR IMAGES THAT WILL BE SUC-FPLXIT73
       CESSIVELY REDUCED BY 1, 1/2, 1/4, AND 1/8 RESPECTIVELY.
C
                                                                          FPLXIT75
                                                                          FPLXIT76
      -MM = NRED**NLAYER
                                                                          FPLXIT77
       NUMPL2 = NUMPPL/MM
                                                                          FPLXIT78
      DO 111 KK1=1.MM
                                                                          FPLXIT79
      DO 111 KK2=1, MM
                                                                          FPLXIT80
                                                                          FPLXIT81
       GET THE FIRST LINE OF DATA FROM DISC FILE 02
                                                                          FPLXIT32
                                                                           FPLXIT93
      00 3 LL=1.KK1
                                                                           FPLXIT84
       READ(2) (IDATA(L,IST),L=1,NUMPPL)
                                                                           FPLXIT95
                                                                           FPLXITS6
      DO 29 J=KK2, NUMPPL, MM
                                                                           FPLXIT87
       N = N + 1
                                                                          FPLXIT98
   29 IDATA(N.IST) = IDATA(J.IST)
                                                                          FPLXIT89
C
                                                                           FPLXIT90
      MMM=MM+KK1
                                                                           FPLXIT91
       DO 1 LONT = MMM. NUMLIN, MM
                                                                           FPLXIT92
       GET THE SECOND LINE OF DATA. AFTER EACH ITERATION. THE OLD SEC-
                                                                           FPLXIT93
                                                                           FPLXIT94
       OND LINE BECOMES THE NEW FIRST LINE.
C
                                                                           FPLXIT95
                                                                           FPLXIT96
       DO 18 LL=1.NM
                                                                           FPLXIT97
   18 READ(2) (IDATA(L, NND), L=1, NUMPPL)
                                                                           FPLXIT98
        N = 0
                                                                           FPLXIT99
       DO 19 J=KK2.NUMPPL.MM
                                                                           FPLXIT00
        N = N + 1
```

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F-P-L-X-I-T

(

JUNE 1973

```
FPLXITOL
       (CHR. L) ATAGE = (GRN . N) ATAGE
                                                                           FPLXIT02
                                                                           FPLXIT03
C
       SET I. L. J. AND K EQUAL TO THE (NORMALIZED) VALUES OF GREY TONESPPLXITO4
C
       OF RESOLUTION CELLS IN POSITIONS (1, IST), (1, NND), (2, IST), AND
Ċ
                                                                           FPLXIT06
       (2.NND) RESPECTIVELY.
                                                                           FPLXITO7
C
                                                                           FPLYITOP
       I = IDATA(1.IST) - LEAST1
                                                                           EPEXIT19
       J = IDATA(2, IST) - LEAST1
                                                                           FPLXIT10
       L' = IDATA(1.NNO) - LEAST1
                                                                           FPLXIT11
       K = IDATA(2,NND) - LEAST1
                                                                           FPI XIT12
       PUT TWO DIMENSIONAL INFORMATION INTO ONE DIMENSIONAL FORM. THE
C
                                                                           FPLXII13
       FUNCTION NEEDED TO CONVERT A DOUBLE SUBSCRIPTED ARRAY, IMM(X,Y)
C
                                                                           FPLXIT14
       INTO A SINGLE SUBSCRIPTED ARRAY, IMM(Z), IS OF THE FORM G(X) +
                                                                           FPLXIT15
C
       F(Y), WHERE G(X) = (X-1)*X/2, AND F(Y) = Y. THEREFORE,
                                                                           FPLXIT16
C
                                                                           FPLXIT17
                    Z = (X-1) + X/2 + Y_*
       THIS IS DONE IN THE PROGRAM BY THE EXTERNAL FUNCTION, INDEX(X,Y). FPLXIT18
C
                                                                            FREXIT19
C
        SINCE THE OPDER OF OCCURRENCE OF THE GREY TONES BELONGING TO A
C
                                                                            FPLXIT20
 Č
        RESOLUTION CELL PAIR IS IMMATERIAL, THE ARRAYS ARE SYMMETRIC.
                                                                            FPLXIT21
        WE LET THE LARGER OF THE TWO HAVE THE FIRST SUBSCRIPT. I.E.
 Ç
                                                                            FPLXIT22
        THE ARRAY IS STORED IN LOWER TRIANGULAR FORM. THE ORDER OF SUB-
 C
                                                                            FPLXIT23
 C
                                                                            FPLXIT24
        SCRIPTING IS AS FOLLOWS.
 C
                                                                            FPLXIT25
                                 IMM(1.1) = IMM(1).
                                                                            FPLXIT26
 C
                                 IMM(2,1) = IMM(2).
 C
                                                                            FPLXIT27
                                 IMM(2,2) = IMM(3)
                                                                            FPLXIT28
                                 IMM(3,1) = %MM(4),
                                                                           FPLXIT?
 CCC
                                                                            FPLXIT30
                                                                            FPLXIT31
                                                                            FPLXIT32
                                 IMM (NOBL , NOBL) = IMM (NBUBL) , WHERE
        NBUBL = NOBL + (NOBL + 1)/2, AND NOBL IS THE TOTAL NUMBER OF GREY
 Č
                                                                            FPLXIT37
                                                                            FPLXIT34
 C
        TONES IN THE APRRAY.
                                                                            FPLXIT35
 C
                                                                            FPLXIT36
        THE SCANNING PROCEDURE, THAT IS, THE METHOD BY WHICH THE PAIR-
                                                                            FPLXIT37
        WISE COMPARISONS ARE MADE, IS DESCRIBED BELOW FOR THE GENERAL
                                                                            FPLXIT3F
 C
                                                                            FPLXIT3C
         CONSIDER A PESOLUTION CELL WITH SPATIAL COORDINATES (M,N), AND
 C
        CASE.
                                                                            FPLXIT40
        CALL THIS CELL "I". THE SCANNING OPERATION BEGINS IN THE UPPER
 C
                                                                             FPLXIT4
        LEFT HAND CORNER OF THE IMAGE (THE FIRST POSITION OF "I" IS IN
                                                                             FPLXIT4
        THAT OF PESOLUTION CELL (1.1) AND IT THEN PROSEEDS BY COMPARING
 C
                                                                            FPLXIT4
         THE GREY TONE OF "I" WITH, AT MOST, FOUR GREY TONES OF ITS NEIGH-FPLXIT4
 C
  C
         BORING RESOLUTION CELLS.
         THAT "I" NEVER NEEDS TO CONSIDER MORE THAN FOUR NEAREST NEIGHBORSEPLXIT4"
         CAN BE SEEN FROM THE DIAGRAM OF THE SEARCH PATTERN SHOWN BELOW
  C
                                                                             FPLXIT4
  C
                                                                             FPLXIT4
                                                                             FPLXITS!
  C
```

FPLXIT51

C

C

C

C

C C C

CGC

C

C

C

C

```
ON A GIVEN ITERATION. "I" WILL LOOK FIRST AT ITS NEAREST VERTIGALEPLXITS:
      NEIGHBOP ("L"). NEXT AT LTS NEAREST HORIZONTAL NEIGHBOR ("J").
                                                                           FPLXITS.
      THIRD AT ITS LOWER RIGHT NEIGHBOR ( "K"), AND FOURTH AT ITS LOWER FPLXITS!
      LEFT DIAGONAL NEIGHB CR ( "M . ) . "I" THE MOVES INTO THE POSITION OFFPLXITS
      THE LEFT-MOST RESOLUTION CELL OF THE PREVIOUSLY SCANNED SECOND FPLXITS!
      ROW (THE POSITION OCCUPIED BY "M"). THE OPERATION IS REPEATED UN-FPLXITS? TIL ALL NEIGHBORING PAIRS OF RESOLUTION CELLS HAVE BEEN EXAMINED. FPLXITS?
                                                                             FPLXIT61
                                                                             FPLXIT5:
       MAKE COUNT FOR THE FIRST TWO COLUMNS.
                                                                             FPLXIT6:
                                                                             FPLXIT6
                                                                             FPLXIT6
       IL = INDFX(I,L)
                                                                             FPLXITE
       COUNT VERTICALLY ADJACENT (99-DEGREE) NEAREST NEIGHBORS FOR FIRSTFPLXITS:
                                                                             FPLXIT6:
       TWO COLUMNS.
                                                                             FPLXITS
                                                                             FPLXIT6'
       LEX1(IL) = LEX1(IL) + 1
                                                                             FPLXIT7
       IR1 = IR1 + 1
                                                                             FPLXIT7!
                                                                             FPLXIT7:
       IJ = INDFX(I,J)
                                                                             FPLXIT7.
       COUNT HORIZONTALLY ADJACENT (0-DEGREE) NEAREST NEIGHBORS FOR THE FPLXIT7
                                                                             FPLXIT7
       FIRST TWO COLUMNS.
                                                                             FPLXIT7
C
                                                                             FPLXIT7
       LEX2(IU) = LEX2(IJ) + 1
                                                                             FPLXIT7
       IR2 = IR2 + 1
                                                                             FPLXIT7
                                                                              FPLXITS
       IK = INDEX(I.K)
                                                                              FPLXITS:
                                                                             FPLXITS'
       COUNT LEFT DIAGONALLY ADJACENT (135-DEGREE) NEAREST NEIGHBORS
C
                                                                              FPLXITS'
       FOR FIRST TWO COLUMNS.
C
                                                                              FPLXITS:
                                                                              FPLXIT8
       LEX3(IK) = LEX3(IK) + 1
                                                                              FPLXITS:
       IR3 = IR3 + 1
                                                                              FPLXITA.
C
                       NOW SHIFT ONE COLUMN TO THE RIGHT AND CONTINUE THE FPLXITS
C
       PROCEDURE FOR GENERAL CASE IN WHICH A RESOLUTION CELL (I) HAS
                                                                              FPLXITA
C
       ONE VERTICAL NEAREST NEIGHBOR (L), ONE HORIZONTAL (J), ONE LOW-
                                                                              FPLXITA
C
       ER RIGHT DIAGONAL (K). AND ONE LOWER LEFT DIAGONAL (M). ITERATE
                                                                              FPLXIT9
C
                                                                              FPLXIT9
       UP TO NEXT TO LAST COLUMN.
C
                                                                              FPLXIT9
                                                                              FPLXIT9
        DO 2 N = 3. NUMPEZ
                                                                              FPLXIT9
       I = J
                                                                              FPLXIT9
        M = L
                                                                              FPLXIT9.
                                                                              FPL XIT9
        J = IDATA(N.IST) - LEAST1
                                                                              FPLXIT9
        K = IDATA(N.NN) - LEAST1
                                                                              FPLXITO
C
```

```
FPLXIT01
       IL = INDEX(I.L)
                                                                            FPLYITO2
C
       COUNT VERTICALLY ADJACENT (90-DEGREE) NEAREST NEIGHBORS.
                                                                            FPLXII03
C
                                                                            FPLXIT04
C
                                                                            FPLXIT05
       LEXI(IL) = LEXI(IL) + 1
                                                                            FPLXII06
       IR1 = IR1 + 1
                                                                            FPLXIT97
C
                                                                            FPLXITOR
       IJ = INDEX(I.J)
                                                                            FPLXITO9
       COUNT HORIZONTALLY ADJACENT (0-DEGREE) NEAREST NEIGHBORS.
                                                                            FPLXIT10
                                                                            FPLXII11
C
                                                                            FPLXIT12
       LEX2(IJ) = LEX2(IJ) + 1
                                                                            FPLXIT13
       IR2 = IR2 + 1
                                                                            FPLXIT14
C
                                                                            FPLXIT15
       IK = INDEX(I,K)
                                                                            FPLXIT16
C
       COUNT "LEFT DIAGONALLY" ADJACENT (135-DEGREE) NEAREST NEIGHBORS. FPL XIT 17
                                                                            FPLXIT18
                                                                            FPLXIT19
       LEX3 (IK) = LEX3 (IK) + 1
                                                                            FPLXIT20
       IR3 = IR3 + 1
                                                                            FPLXIT21
C
                                                                            FPLXIT22
       IM = INDEX(I,M)
                                                                            FPLXIT23
       COUNT "RIGHT DIAGONALLY" (45-DEGREE) ADJACENT NEAREST NEIGHBORS. EPLYST24
C
                                                                            FPLXIT25
C
                                                                            FPLXIT25
       LEX4(IM) = LEX4(IM) + 1
                                                                            FPLXIT27
       IR4 = IR4 + 1
                                                                            FRLXIT28
C
                                                                            FPLXIT29
       CONTINUE
   2
                                                                            FPLXIT30
C
                                                                            FPLX1T31
        MAKE COUNT FOR LAST COLUMN.
C
                                                                            FPLXIT3?
                                                                            FPLXIT33
        I = J
                                                                            FPLXIT34
        M = L
                                                                             FPLXIT35
        L = K
                                                                            FPLXIT36
C
                                                                             FPLXIT37
        IL = INDEX(I,L)
                                                                             FPLXIT38
                            ADJACENT NEAREST NEIGHBORS FOR LAST COLUMN.
                                                                             FPLXIT39
        COUNT VERTICALLY
                                                                             FPLXIT48
                                                                             FPLXIT41
        LEX1(IL) = LEX1(IL) + 1
                                                                             FPLXIT42
        IR1 = IR1 + 1
                                                                             FPLXIT43
 C
                                                                             FPLXIT44
        IN = INDEX(I,M)
                                                                             FPLXIT45
 C
       COUNT 'RIGHT DIAGONALLY' ADJACENT NEAREST NEIGHBORS FOR THE LAST
                                                                             FPLXIT46
 C
                                                                             FPLXIT47
        COLUMN.
 C
                                                                             FPLXIT48
                                                                             FPLXIT49
        LEX4(IM) = LEX4(IM) + 1
                                                                             FPLXIT50
        IP4 = IR4 + 1
```

```
FPLXIT51
                                                                            FPLXIT5?
       INTERCHANGE THE LINE POINTERS.
                                                                            FPLXIT53
C
                                                                            FPLXIT54
C
                                                                            FPLXIT55
       MN = IST
       IST = NNO
                                                                            FPLXIT56
       NM = GNN
                                                                            FPLXIT57
                                                                            FPLXIT58
C
       CONTINUE
                                                                            FPLXIT59
                                                                            FPLXIT60
C
       MAKE COUNT FOR LAST ROW.
                                                                            FPLXIT61
                                                                            FPLXIT62
C
        I=IDATA(1,IST) - LEAST1
                                                                            FPLXIT63
        J=IDATA(2,IST) - LEAST1
                                                                             FPLXIT64
                                                                             FPLXIT69
C
        IJ = INDEX(I,J)
                                                                             FPLXIT66
        COUNT HORIZONTALLY ADJACENT NEAREST NEIGHBORS FOR FIRST TWO COL- FPLXITS7
C
C
        UMNS OF LAST ROW.
                                                                             FPLXITSC
C
                                                                             FPLXIT70
.C
        LEX2(IJ) = LEX2(IJ) + 1
                                                                             FPLXIT71
        IR2 = IR2 + 1
                                                                             FPLXIT7
                                                                             FPLXIT7
 C
        COMPLETE COUNT FOR LAST ROW.
 C
                                                                             FPLXIT71
                                                                             FPLXIT7
        00 12 N = 3, NUMPL2
                                                                             FPLXIT7
                                                                             FPLXIT77
        I = J
        J = IDATA(N.IST) - LEAST1
                                                                             FPLXIT7
                                                                             FPLXIT7
 C
        IJ = INDEX(I.J)
                                                                             FPLXIT8
        COUNT HORIZONTALLY ADJACENT NEAREST NEIGHBORS FOR REMAINDER OF
                                                                             FPLXITS'
 C
                                                                             FPLXITS
 C
        LAST ROW.
                                                                             FPLXIT9
 C
                                                                              FPLXIT8
        LEX2(IJ) = LEX2(IJ) + 3
                                                                              FPLXITS:
         192 = 192 + 1
                                                                              FPLXITS.
                                                                              FPLXIT9
         CONTINUE
   12
         BENIND 05
                                                                              FPLXIT8
        CONTINUE
                                                                              FPLXIT9
  111
                                                                              FPLXIT9
 C
         NOW DOUBLE THE DIAGONAL TO MAKE EVERYTHING COME OUT RIGHT
                                                                              FPLXII9
 C
                                                                              FPLXIT9
 C
                                                                              FPLXIT9
 C
        NOBL=11-12+1
                                                                              FPLXIT9
        00 100 I=1.NOBL
                                                                              FPLXIT9
        II=INDFX(I,I)
                                                                              FPLXIT9
        LEX1(II)=2*LEX1(II)
                                                                              FPLXIT9
        LEX2(II)=2*LEX2(II)
                                                                              FPLXIT9
        LEX3(II)=LEX3(II)*2
                                                                              FPLXIT9
                                         REPRODUCIBILITY OF THE
        LEX4(II)=LFX4(II) *2
                                                                              FPLXII0
                                         ORIGINAL PAGE IS POOR
    100 CONTINUE
```

F-P-L-X-I-T

02-09-74 20.451

JUNE 1973

	IF (.NOT.MERGE) RETURN	FPLXITO FPLXITO
C	IF MERGE IS TRUE, SUM ALL APRAYS INTO LEXI	FPLXITO
. 0	00 112 I=1,NBU9L LEX1(I)=LEX1(I)+LEX2(I)+LEX3(I)+LEX4(I)	FPLXITO
112	CONTINUE PETUPN END	FPLXITO FPLXITO FPLXITO

769 WORDS OF MEMORY USED BY THIS COMPILATION

```
INDEX001
                      I-N-0-E-X
                                                                             INCFX002
CINDEX
                                                                             INDEX003
                                                               SEPT 1971
      WRITTEN BY RMH
                                                                             INDEXOUG
Ċ
       GIVEN THE ROW AND COLUMN SUBSCRIPTS I AND L. INDEX RETURNS
                                                                             INDEXOUS
C
                                                                             POOKECNI
C
       THE SINGLE SUBSCRIPT FOR THE LEX ARRAY INDICATING WHERE
C
                                                                             INCEX007
       ELEMENT (I.L) CAN ME FOUND.
                                                                             INDEXOGR
Ċ
                                                                             INCEXOUS
CCC
                                                                             INDEXO10
         1
                                                                             INDEX011
               3
          2
                                                                             INDEX012
               5
                    6
C
                                                                             INDEX01:
                        1.0
CCC
                                                                             INDEX 114
                                                                              INDEXO15
        FUNCTION INDEX(I,L)
                                                                              INDEX016
        INDEX1(I,L) = (I-1)*I/2 + L
                                                                              INDEX01
        IF(I.GT.L) GO TO 1
                                                                              INDEX01
        INDEX = INDEX1(L.I)
                                                                              INDEX81'
        RETURN
                                                                              IND EXO 2!
        INDEX = INDEX1(I.L)
                                                                              INDEXOZ:
        RETURN
                                                                              INCEXUZ:
        END
```

```
IMOMTRO1
                                                              JUNE 1973
                         I-M-0-M-T-R
                                                                            IMONTR02
CIHOMTR
                                                                            IMOMIR03
                                                              SEPT 1971
      WOITTEN BY RMH
                                                                            IMONTRO4
      VERSION 1 BY SAM SHANMUGAM FOR LAWRENCE DATA
                                                              JUNE 1972
                                                              JUNE 1973
                                                                            INOMTR05
      VERSION 2 BY RJ BOSLEY FOR MERGE OPTION
                                                                            IMONTRO6
                                                                            IMONTRO7
      DESCRIPTION OF PROGRAM.
         THIS PROGRAM CALCULATES THE MOMENT TEXTURE STATISTICS (AS
                                                                             IMOMTROB
                                                                             INOMTRO9
      DEFINED BELOW UNDER TEXTURAL FEATURES) FROM THE LEX ARRAYS.
                                                                             IMOMIR 10
       ACCORDING TO THE MERGE OPTION.
                                                                             IMOMTR11
                                                                             IMOMTR12
                                                                             IMOMTR13
       ENTRY POINT.
                                                                             IMONTR14
          CALL IMONTR(_EX1,LEX2,_EX3,LEX4,F,1Q,MERGE)
                                                                             IMONTR15
                                                                             IMOMTR16
                                                                             IMONTR17
                                    ADDRESS INDEXS FOR LEX ARRAYS
C
       ARGUMENTS .
               LEX1-LEX4
                                                                             IMOHTR18
                                     CUMULATIVE DISTRIBUTION FUNCTION
                                    QUANTIZED OUTPUT ARRAY OF LEQPO1
                                                                             IMOMIR19
 C
                                    OPTION TO MERGE THE FOUR _EX ARRAYS
                                                                             IMOMTR20
               In
               MERGE
 Č
                                                                             IMONIR21
                                        INTO ONE ARRAY
                                                                             IMOMTR22
 Ç
                                                                             IMONTR23
       INTERNAL PARAMETERS.
                                                                             TMOMTR74
 C
                                     TEXTURAL FEATURES -- SEE BELOW
               ANGMOM . . . CORMAX
                                     NUMBER OF QUANTIZING LEVELS FOR LEGPQ1:MOMTR25
                NQUANT
                                                                             IMOMTR25
                                     THICE NQUANT
                NQUAN2
                                     MAXIMUM NUMBER OF GREY TONE LEVELS
                                                                             THOMTR27
                IMAX
                                                                             IMOMTR28
                                     MINIMUM NUMBER OF GREY TONE LEVELS
                                                                              IMOMT929
                IMIN
                                     THE NUMBER OF RESOLUTION CELL PAIRS
 C
                IR1-IR4
                                                                              IMOMTR30
 C
                                     THVERSE OF IR1-IR4
                                                                              INOMTR31
                R1-R4
 C
                                        COUNTED IN EACH LEX ARRAY
                                     SCRATCH ARRAY USED BY SUBROUTINE COR
                                                                             IMOMTR32
 C
                QD
                                                                              IMONTR33
 C
                                     ARRAY OF JOINT PROBABILITIES
                P(XY)
                                                                              THOMT934
 C
                                     NUMBER OF GREY TONE LEVELS
                NOBL
                                                                              IMOMTR35
                                     SUM OF ELEMENTS OF THE LEX ARRAY
                NADD1-NADD4
                                                                              IMONTR36
                                                                              IMOMTR37
        TEXTURAL FEATURES.
                                                                              IMOMTR38
 C
         ANGMOM= SUM SUM P(I,J) *P(I,J)
                                                                              IMONTR39
                                                                              IMOMTR40
 C
                                                                              IMOMTR41
 C
                                                                              IMOMTR42
         AMEAN= SUM SUM T*P(I,J)
                                                                              IMONTR43
                                                                              IMOMTR44
                                                                              IMOMTR45
                                                                              IMOMTR46
  C
         AMEAN= SUM SUM J*P(I.J)
                                                                              IMOMTR47
  C
                                                                              IMOMTR48
                                                                              IMONTR49
                                                                              IMOMTR56
         SGMASQ = SUM SUM ((I-AMEAN) **2) *P(I.J)
```

```
IMOMTR51
                 I
                      J
C
                                                                               IMOMTR52
                                                                               IMONTR53
                                                                               IMONTR54
       SGHASQ= SUM SUY ((J-AMEAN) ++2) +P(I,J)
                                                                               IMONTR55
C
                                                                               IMONTR56
C
                                                                               IMONT957
S
                                                                               I HOMTRES
        SGMAXY= SUM SUM (I-AMEAN) +J-AMEAN) P(I,J)
                                                                               IMOMTR59
C
                                                                               IMOMTRED:
                                                                               IMOMTR61
C
                                                                               IMOMT962
        IVDMOM= SUM SUM (P(I,J)/(1+(I J)**2)
C
                                                                               IMOMIR63
C
                                                                               IMOMTR64
Ç
                                                                               IMOMTR65
CCC
                                                                               IMOMTR65
        RATIO=SGMAXY/SMGASQ
                                                                               IMOMTR67
                                                                               IMOMTR68
CCC
                                                                               IMONTR69
        ENTROP=-SUM SUM P(I,J)LOG(P(I,J))
                                                                               IMOMTR70
C
                                                                                IMOMTR71
C
                                                                                IMOMTR72
                                                                                IMOMTR73
C
                                                                                IMOMTR74
       DIF(K) = SUM SUM P(I,J)
                                                                                IMONTR75
              ABS (I-J)=K
C
                                                                                IMOMTR 76
Ç
                                                                                IMOMIR77
       SUM(K) = SUM SUM P(I,J)
 C
                                                                                IMOMTR78
                  I+J=K
                                                                                IMOMTR79
 C
                                                                                IMONT980
       DIFERT = SUM DIF(K)*LOG(DIF(K)) *(-1)
 C
                                                                                IMOMTR81
 CCC
                                                                                IMOMTR82
                                                                                IMOMTR93
       DIFAVE = SUM K*DIF(K)
                                                                                IMONTR84
 C
                                                                                IMOMTR85
 C
                                                                                IMOMTR85
       DIEVAR IS THE VARIANCE OF THE DISTRIBUTION DIF
 C
                                                                                IMOMTR87
 C
                                                                                IMOMT988
 C
                                                                                IMOMTR89
        NOTE THAT
 C
                                                                                IMOMTR93
                DIFMOM=2 * (SGMASQ-SGMAXY)
 C
        THE INTEGERS 1,2,3,4 FOLLOWING THE VARIABLE NAMES CORRESPONDE TO
                                                                                IMOMT391
 C
                                                                                IMONTR92
        THE FOUR ANGLES--
 C
                                                                                IMOMT933
 C
                                                                                IMOMTR94
                                             ANGLE
                     SUBSCRIPT
 C
                                                                                IMOMTR95
                 LEX ARRAY MOMENT ARRAY
 CCC
                                                                                INOMTR95
                                                                                IMONTR97
                                              90 DEGREES
                                   3
                                                                                INOMTR98
                                               0 DEGREES
                                   1
 C
                                                                                INOMT99
                                              135 DEGREES
                     3
                                                                                INOMTROO
                                              45 DEGREES
 C
```

```
IMONTRA1
       IF MERGE IS .TRUE.. THE FOUR LEX ARRAYS HAVE BEEN MERSED INTO
                                                                               IMOMTR82
Č
                                                                               IMOMTRO3
C
      LEX1.
                                                                               IMOMTRO4
C
                                                                               IMONTROS
      SUBROUTINE IMONTR(LEX1, LEX2, LEX3, LEX4, F, 10, MERGE)
                                                                               IMONTROS
                                                                               IMONTRO7
C
                                                                               IMOMITADA
      REAL IVOMOM
                                                                               IMONTROY
      LOGICAL MERGE
                                                                               IMONTP16
       DIMENSION LEXI(1), LEX2(1), LEX3(1), LEX4(1)
                                                                               IMOMTR11
       DIMENSION F(64), In(64)
                                                                               IMOMTR12
       DIMENSION DIF1(64), DIF2(64), DIF3(64), DIF4(64)
       DIMENSION SUM1 (128) . SUM2 (128) . SUM3 (128) . SUM4 (128)
                                                                               IMOMIR13
                                                                                IMOMÍR14
        TIMENSION P(3600),00(300)
                                                                                IMOMTR15
       EQUIVALENCE (P(1)+Q2(1))
                                                                                IMOMT916
       COMMON /Q/ NQUANT
                                                                                IMOMTR17
       COMMON M1.N1, TYPE, G(14)
       COMMON IMAX IMIN, NUMPPL, NUMLIN, NBUBL, IR1, IR2, IR3, IR4, ANGMOM(4),
                                                                                TMOMIRIA
      1 AMEAN(4) -SGMAS(4) -SGMAXY(4) -DIFMOM(4) -RATIO(4) -IVDMOM(4) -TMEAN
                                                                                IMOMTR19
       SOMMON /EC/ENTROP(4), D_FENT(4), DIFAVE(4), DIFVAR(4), SUMENT(4),
                                                                                IMOMTR28
                                                                                IMOMTR21
      1SUMAVE(4) +SUMVAP(4)
                                                                                IMOMTR22
       COMMON /CORREL/CORINE (4), CORMUT (4), CORMAX (4)
                                                                                IMOMTR23
C
                                                                                IMOMTR24
        INITIALIZE ARRAYS TO ZERO
C
                                                                                IMONTR25
                                                                                IMOMTR?E
       00 1 I=1,4
                                                                                IMONTR27
       IVDMOM(I) = 0
                                                                                IMOMTR28
       ANGMOM(1)=0
                                                                                IMOMTR29
       AMEAN(I)=0
                                                                                IMONTR30
       SGMASQ(I)=0
                                                                                IMOMTR31
       SGMAXY(I)=0
                                                                                IMOMTR32
       ENTROP(I) =0.0
                                                                                IMONTR33
                                    REPRODUCEDILITY OF THE
       DIFENT(I)=0.0
                                                                                IMOMTR34
                                    ORIGINAL PAGE IS POOR
       DIFAVE(I) = 0.0
                                                                                IMOMTR35
       D_FVAR(I) = 0.0
                                                                                IMONTR36
        SUMENT(I)=0.0
                                                                                IMONTR37
        SUMAVF(I)=0.0
                                                                                IMONTR38
       SUMVAR(I)=0.0
                                                                                IMOMTR39
     1 PATIO(I)=0
                                                                                IMOMTP40
       DO 36 K=1+NQUANT
                                                                                IMOMTR41
       0.F1(K) = 0.0
                                                                                IMONTR42
       DIF2(K) = 0.0
                                                                                IMONTR43
       DIF3(K)=0.0
                                                                                IMOMTR44
        D. F4 (K) =0 . 0
  86
                                                                                IMOMTR45
        NQUAN2=2*NQUANT
                                                                                INDMTR46
        DO 87 KS=1, NOUANZ
                                                                                IMOMTR47
        S'IM1 (KS) = 0.0
                                                                                 TMOMTR48
        SUM2 (KS) = 0.0
                                                                                 IMONTR49
        SUM3 (KS) = 0 . 0
                                                                                 INONTR50
        SUM4 (KS) = 0.0
  87
```

```
IMONT951
                                                                             IMONTR52
       GET THE NUMBER OF BRIGHTNESS LEVELS, NOBL
C
       IF THE LEX ARRAY WERE SQUARE AND NOT COMPACTED. IT WOULD BE
                                                                             IMOMTR53
C
                                                                             IMOMTR54
       UIMENSIONED NOOL BY NOOL
                                                                             IMOMTR55
                                                                             IMONTR56
      NOBL=IMAX-IMIN+1
                                                                             IMOMTR57
C
       NOW OFTERMINE THE TOTAL NUMBER OF RESOLUTION CELL PAIRS
                                                                             IMOMTR58
C
                                                                             IMOMTR59
       COUNTED IN EACH OF THE LEX ARRAYS
                                                                             IMONTREG
                                                                             IMOMTR61
      T?1=0
                                                                             IMONT962
      IR2=0
                                                                             IMONTR63
      IR3=0
                                                                             IMOMTR64
      194=0
                                                                             IMONTR65
      IF (.NOT.MERGE) GO TO 40
                                                                             INOMTR66
      00 42 I=1.NOPL
                                                                             IMOMTR67
      DU 42 J=1.NOEL
                                                                             IMOMTR68
      IJ=INDEX( ,J)
                                                                             IMOMTR69
      IR1=IR1+LFX1(IJ)
                                                                             IMOMTR70
      CONTINUE
                                                                             IMOMTR71
      R1=1./FLOAT(IR1)
                                                                             IMOMTR72
      GO TO 41
                                                                             IMONTR73
      00 5 I=1,NO3L
40
                                                                             IMOMTR74
      DO 5 J=1,NO9L
                                                                             IMOMTR75
      IJ=INDEX(I,J)
                                                                             IMOMTR76
       IR1=IR1+LFX1(IJ)
                                                                              IMOMTR77
       IR2=IR2+LFX2(IJ)
                                                                             IMOMTR78
       IR3=IR3+LEX3(IJ)
                                                                             IMONTR79
    5 IR4=IR4+LEX4(IJ)
                                                                             IMOMIRSO
                                                                              IMOMTR81
       GET R1,R2,R3,R4 TO SAVE DIVISIONS
C
                                                                              IMOMTR82
C
                                                                              IMOMTR83
       R1=1./FLOAT(IP1)
                                                                              IMOMT284
       R2=1./FLOAT(IR2)
                                                                              IMOMTR85
       R3=1./FLOAT (IR3)
                                                                              IMOMTR86
       R4=1./FLOAT(IR4)
                                                                              IMOMTR87
                                                                              38 STMOMI
       FIND THE CORRELATION MEASURES
C
       PUT THE LEX ARRAYS IN P MATRIX AND CALL CORRELATION ROUTINE
                                                                              IMOMTR89
C
                                                                              IMOMTRAD
C
                                                                              IMOHTR91
        DO LEXZ ARRAY
                                                                              IMONTR92
                                                                              IMOMTR93
       JJ=0
                                                                              IMOMTR94
       00 201 I=1,NORL
                                                                              IMONTR95
       00 201 J=1,NOBL
                                                                              IMONT996
       IJ=INDEX(_+J)
                                                                              IMOMTR97
       JJ=JJ+1
                                                                              IMOMTR98
      P(JJ)=FLOAT(LEX2(IJ)) *R1
                                                                              IMONTR99
       CALL COR(P, NOS_, 1,QD, COR1, COR2, COR3)
                                                                              INOMTROD
       CORINF(1) = COR1
```

```
I MOMTRO1
      CORMUT(1) = COR2
                                                                              IMONTRO2
      CORMAX(1)=COR3
                                                                              IMONTRO3
      JJ=0
                                                                              IMOMTRO4
                                                                              IMOMEROS.
       DO LEX4 ARRAY
                                                                              IMOMTRO6
                                                                              IMONTR07
      DO 211 I=1,NOPL
                                                                              IMONIROB
      00 211 J=1.NOBL
                                                                              PESTMONI
      IJ=INDEX(T,J)
                                                                              IMO4FR10
      JJ=JJ+1
                                                                              IMOMTR11
      P(JJ) =FLOAT(LEX4 (_J)) #R?
 211
                                                                              IMOMTR12
      CALL COR(P, NOBL, 1, Q5, COR1, COR2, COR3)
                                                                              IMOMTP13
      CORINE(2) = COR1
                                                                              IMOMTR14
      CORMUT(2) =COP2
                                                                              IMONTR15
      CORMAX(2)=COR3
                                                                              IMOMTR16
41
      JJ=0
                                                                               IMONTR17
C
                                                                               IMONTR18
C
       DO LEX1 ARRAY
                                                                              IMOMTR19
                                                                               IMOMTREB
      DO 221 I=1,NOBL
                                                                               IMOMTR21
      00 221 J=1,NOBL
                                                                               IMONTR22
      IJ=INDEX(I,J)
                                                                               IMOMTR23
      JJ=JJ+1
                                                                               IMOMTR24
     P(JJ)=FLOAT(LEX1(IJ))*R1
                                                                               IMOMTR25
      CALL COR(P, NOB_, 1,QD, COR1, COR2, COR3)
                                                                               IMOMTR26
      CORINF(3) = COR1
                                                                               IMONT927
      CORMUT(3) =COR2
                                                                               IMOMTR28
      CORMAX(3)=COR3
                                                                               IMONTR29
      IF (MERGE) GO TO 43
                                                                               IMOMTR30
       JJ=0
                                                                               IMONTR31
                                                                               IMONTR32
       DO LEX3 ARRAY
                                                                              #MOYTR33
                                                                               INOMIR34
      DO 231 I=1,NO8L
                                                                               IMOMTR35
       DO 231 J=1,NO9L
                                                                               IMONT936
       IJ=INDEX(I,J)
                                                                               IMOMTR37
       JJ=JJ+1
                                                                               IMONTR38
      P(JJ)=FLOAT(LEX3(IJ)) #R4
                                                                               IMOMTR39
       CALL COR(P, NOB_, 1,QD, COR1, COR2, COR3)
                                                                               IMOMTR40
       CORINF (4) =COR1
                                                                               IMONTR41
       CORMUT(4) = COP2
                                                                               IMOMTR42
       CORMAX(4) =COR3
                                                                               IMOMTR43
C
                                                                               IMOMTR44
       GET THE PROBABILITY FUNCTION IN F
C
                                                                               IMONTR45
C
                                                                               IMOMTR46
       DO 379 I=1,64
43
                                                                               IMONTR47
       D=(I) 01
                                                                               IMONTR48
   379 F(I)=0
                                                                               IMONTR49
        IF MERGE. GO TO SECTION I TO MAKE THE COMPUTATIONS
                                                                               IMONTR50
C
```

```
INOHIR51
C
                                                                             IMONTR52
      IF (MERGE) GO TO 911
                                                                             IMONTR53
      DD 6 I=1, NO3L
                                                                             IMOMT954
      IA=0
                                                                             IMONIR55
      DO 7 J=1, NOBL
                                                                             INOMTR56
      IJ=INDEX(I,J)
                                                                             IMOMTR57
    7 IA=LA+LEX1(IJ)+LEX2(IJ)+LEX3(IJ)+LEX4(IJ)
                                                                             IMOMTR58
    6 F(I) =FLOAT(IA) /FLOAT(IR1+IR2+_R3+IR4)
                                                                             IMONT459
                                                                             IMONTR50
       FIRST COMPUTE THE TRUE MEAN
C
                                                                             IMOMTR61
                                                                             IMONTR62
      TMEAN=0
                                                                             IMONTR63
      00 10 I=1,NORL
                                                                             IMOMTR64
   10 THEAN=THEAN+F(I) *FLOAT(;)
                                                                             IMONTR65
      TMEAN=TMEAN+FLOAT (IMIN-1)
                                                                             IMONTR66
                                                                             IMONTR67
       GET CUMULATIVE DISTRIBUTION FUNCTION IN F
C
                                                                             IMOMTR68
C
                                                                              IMOMTR69
      DO 8 I=2, NOBL
                                                                              IMONTR70
    8F(I)=F(I)+F(I-1)
                                                                              IMOMTR71
C
                                                                              IMONTR72
        DETERMINE THE QUANTIZING FUNCTION
                                                                              IMONTR73
                                                                              IMONTR74
      CALL IEQPO1(NOBL, NQUANT, F, IQ, IMIN)
                                                                              IMONTR75
¢
                                                                              IMOMTR76
        NEXT COMPUTE THE QUANTIZED TRANSLATED MEAN FOR EACH ARRAY
                                                                              IMOMTR77
                                                                              IMOMTR78
       DO 2 I=1, NQUANT
                                                                              IMOMTR79
       DO 2 J=1 NQUANT
                                                                              IMOMTR80
       NSI=1
                                                                              IMONTR81
       IF (I.NE.1) NSI=IQ(I-1)+2-1MIN
                                                                              IMOMTR82
       NEI=IQ(I)-IMIN +1
                                                                              IMOMTR83
       NSJ=1
                                                                              INOMTR84
       IF (J.NF.1) NSJ=IQ(J-1)+2-_MIN
                                                                              IMOMTR85
       NFJ=IQ(J) -IMIN +1
                                                                              IMOMTR86
       IF (NSI.GT.NEI) 50 TO 2
                                                                              IMONTR87
       IF (NSJ.GT.NEJ) GO TO 2
                                                                              IMOMTR88
       NADD1=8
                                                                              IMONTR89
       NADD2=0
                                                                              IMOMTR90
       NADD3=0
                                                                              IMOMIR91
       NADD4=0
                                                                              IMOMTR92
       DO 9 NI=NSI, NEI
                                                                              IMONTR93
       DO 9 NJ=NSJ,NEJ
                                                                              IMONTR94
       IJ#INDEX(NI,NJ)
                                                                               IMOMTR95
       NADD1=NADD1+LFX1(TJ)
                                                                              IMOMTR96
       NADD2=NADD2+LFX?(TJ)
                                                                              IMONTR97
       NADD3=NADD3+LEX3(IJ)
                                                                               IMONTR98
     9 NADD4=NADD4+LEX4 (IJ)
                                                                               IMONTR99
       AMEAN(1) = AMEAN(1)+FLOAT(NAODZ* I)
                                                                               IMOMTROO
       AMEAN(4) = AMEAN(4) +FLOAT (NADD3*I)
```

```
IMOMTRO1
    AMEAN(2) = AMEAN(2) + FLOAT (NAOD4* I)
                                                                             IMONTR02
    AMEAN(3) = AMEAN(3) +FLOAT(NADC1* I)
                                                                             IMONTRO3
                                                                             IMOMTR04
  2 CONTINUE
                                                                             INOMIROS
      NOW NORMALIZE TO GET THE HEANS
                                                                              IMOMTROE
                                                                              IMOMTR07
     AMEAN(1) = AMEAN(1) # 92
                                                                              IMOMT90*
     AMEAN(2) = AMEAN(?) #04
                                                                              IMOMIROS
     AMEAN (3) = AMEAN (3) #R1
                                                                              IMOMTP1[
     AMEAN (4) = AMEAN (4) *R3
                                                                              IMOMTRA:
                                                                              IMOMTRIE
      NOW DO MOMENT CALCULATIONS
                                                                              IMOMTR1:
                                                                              IMOMTR14
     DO 3 T=1, NQUANT
                                                                              IMOMTR15
     DO 3 J=1, NQUANT
                                                                              IMOMTRA
     NSI=1
                                                                              IMOMTR17
     IF (I.NE.1) NSI=IQ(I-1)+2-IMIN
                                                                              IMOMT91
     NEI=IQ(I) -IMIN +1
                                                                              IMOMTR1
                                                                              IMOMTR2:
     NSJ=1
     IF (J.NE.1) NSJ=IQ(J-1)+2 -IMIN
                                                                              IMOMTR2:
                   -IMIN +1
                                                                              IMOMTRE:
     NFJ=IQ(J)
      IF (NSI.GT.NEI) GO TO 3
                                                                              IMOMT92
      IF (NSJ.GT.NEJ) GO TO 3
                                                                              IMOMTR2.
                                                                              IMOMT32
      NADD1=0
                                                                              IMONTE?
      NADD2=0
                                                                               IMOMTR2
      NA DD 3=0
                                                                               IMOMT92
      NADD4=0
      DO 13 NI=NSI,NEI
                                                                               IMOMTP2
                                                                               IMOMT93
      DO 13 NJ=NSJ.NEJ
                                                                               IMOMT23
      NINJ=INDEX(NI,NJ)
                                                                               IMOMT93
       SUM UP THE ELEMENTS IN EACH LEX ARRAY
                                                                               IMOMTR3
C
                                                                               IMOMTR3
C
      NAOD1=NAOF1+LEX1 (NINJ)
                                                                               IMOMTR3
      NADDZ=NADDZ+LEX2 (NINJ)
                                                                               IMOMTR3
                                          ORIGINAL PAGE IS POOR
      NA DO3=NADD3+LFX*(NINJ)
                                                                               IMOMT93
   13 NADD4=NADD4+LEX4 (NINJ)
                                                                               IMOMIR3
                                                                               IMOMTR3
C
                                                                               IMOMTR4
        NORMAL IZE
                                                                               IMONT94
       RL1=FLOAT (NADD1) *R1
                                                                               IMOMTR4
       RL2=FLOAT (NADO2) *R2
                                                                               IMOMTR4
       RL3=FLOAT (NACO3) *R3
                                                                               IMONTR4
       RL4=FLOAT (NADD4) *R4
                                                                                IMOMTR4
                                                                                IMONTR4
        CALCULATE THE MOMENTS
                                                                                IMOMTR4
C
                                                                                IMOMTR4
        ANGMOM (1) = ANGMOM (1) +PL2**2
                                                                                IMOMTR4
       ANGHOM (2) = ANGMOM (2) +PL4##2
                                                                                IMONTR5
       ANGHOM (3) = ANGHOM (3) +RL1**?
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IMOMTR51
      ANGMOM(4) = ANGMOM(4) +PL3**?
                                                                               IMOMTRES2
     SUMASO(1) =SGMASO(1)+((FLOAT(I)-AMEAN(1))**2) *R.2
                                                                              IMOMTR57
      SSMASQ(2)=SGMASQ(2)+((FLOAT(_)-AMFAN(2))**2)*?_4
                                                                              IMOMIRS4
      SGMASQ(3) =SGMASQ(3)+((FLOAT(I)-AMEAN(3))**2)*PL1
                                                                              IMOMTR55
      SSMASQ(4) = SGMASQ(4) + ((FLOAT(I) - AMEAN(4)) + 2) + 2L3
      SGMAXY(1)=SGMAXY(1)+(FLOAT(I)-AMFAN(1))+(FLOAT(J)-AMEAN(1))+PL2
                                                                               IMONTR56
      SCMAXY(2) = SGMAXY(2) + (FLOAT(I) - AMEAN(2)) + (FLOAT(J) + AMEAN(2)) + PL4
                                                                               IMONT257
      SGMAXY(3) =SGMAXY(3) + (FLOAT(1) -AMEAN(3)) + (FLOAT(J) -AMEAN(3)) + RL1
                                                                               IMONTQ58
                                                                               IMONTR59
      SGMAXY(4)=SGMAXY(4)+(FLOAT(1)-AMEAN(4))*(FLOAT(J)-AMEAN(4))*RL3
                                                                               IMOMIR50
      TVDMOM(1)=IVDMOM(1)+RL2/(1.+FLOAT((I-J)**2))
                                                                               IMOMTR61
      IVOMOM(2) = IVOMOM(2) + PL4/(1.+F_OAT((I-J) **2))
                                                                               IMONTR62
      IVOMOM(3)=IVOMOM(3)+RL1/(1.+FLOAT((:-J)**?))
                                                                               IMOMTR63
      IVOMOM(4) = IVOMOY(4) + RL3/(1. + FLOAT((I-J) **2))
                                                                               IMOMTR64
      IF (RL2.LT.0.000001) GO TO 50
                                                                               IMOMT955
      ENTROP(1) =FNTROP(1) -RL2 *ALOG (RL2)
                                                                               IMONTREE
      IF(RL4.LT.0.000001)GO TO 51
                                                                               IMONTR67
      ENTROP(2) = ENTROP(2) -RL4 *ALOG(RL4)
                                                                               IMONTR68
      IF (RL1.LT.0.000001)GO TO 52
51
                                                                               IMONTR69
      ENTROP(3) =ENTROP(3) -RL1*A_OG(RL1)
                                                                               IMOMT970
      IF (9L3.LT.0.000001) GO TO 53
52
                                                                               IMOMTR71
      ENTROP(4) = ENTROP(4) -RL3*A_OG(RL3)
                                                                               IMOMTR72
53
      CONTINUE
                                                                               IMOMTR73
                                                                               IMONTR74
      SET UP THE SUM ARRAY
                                                                               IMOHTR7F
С
                                                                               IMOMTR78
      K=IABS(I-J)+1
                                                                               INOMTR77
C
                                                                               IMOMTR78
      SET UP THE DIFFERENCE ARRAY
C
                                                                               IMOMTR79
C
                                                                               IMONTRAL
      KS=IABS(I+J)+1
                                                                               IMOMTR81
      DIF1(K)=DIF1(K)+RU2
                                                                               IMOMTR82
      DIF2(K)=D_F2(K)+RL4
                                                                               IMOMTRAG
      DIF3(K) = 0.F3(K) + RL1
                                                                               IMOMT984
      DIF4(K)=DIF4(K)+RL3
                                                                               THOMTR85
      SUM1 (KS) = SUM1 (KS) + RL2
                                                                               IMONTSBE
       SUM2 (KS) = SUM2 (KS) +RL4
                                                                               IMOMT387
       SUM3 (KS) = SUM3 (KS) + RL1
                                                                               IMOMTR88
       SUM4 (KS) = SUM4 (KS) +RL3
                                                                               IMOMTR89
       CONTINUE
 3
                                                                                IMOMT990
       00 4 I=1.4
                                                                                IMOMTR91
    4 RATIO(I)=SGMAXY(I)/SGMASQ(I)
                                                                               IMONTR9?
       CALCULATE THE ENTROPY, AVERAGE, AND THE VARIANCE OF THE DIFFERENCE
                                                                               IMOMTR93
                                                                                IMONTR94
C
       ARRAY
                                                                                1 MOMTR9F
                                                                                IMOMTR90
       DO 31 K=1, NOUANT
                                                                                IMOMTR97
       IF (DIF1(K).LT.0.000001) GO TO 54
                                                                                IMONT998
       DIFENT(1) = DIFFNT(1) - DIF1(K) *ALOG(DIF1(K))
                                                                                IMONTR9¢
       IF (01F2 (K) . LT. 0. 000001) GO TO 55
  54
                                                                                IMONTROF
       DIFENT(2) = DIFENT(2) - DIF2(K) *ALOG(DIF2(K))
```

```
IMOMTRO1
     IF(0IF3(K).LT.0.000001) GO TO 56
                                                                               IMOMTR02
     DIFFNI(3) = DIFENI(3) -D.F3(K) *ALOG(DIF3(K))
                                                                               IMOMTROS
     IF(DIF4(K).LT.0.000001) GO TO 57
                                                                               IMONTE CA
56
     DIFENT(4) =DIFENT(4) -DIF4(K) *ALOG(DIF4(K))
                                                                               IMOMT905
     CONTINUE
                                                                               IMOMTRAG
57
     G=FLOAT(K)
                                                                               IMOMTRO7
      DIFAVE(1) =DIFAVE(1) + (G*DIF1(K))
                                                                               TMOMTROE
      DIFAVE(2) =DIFAVE(2) + (6*01F2(K))
                                                                                THOMTPOF
      DIFAVE(3) = DIFAVE(3) + (G*0_F3(K))
                                                                                IMOMTRIC
      DIFAVE(4) = DIFAVE(4) + (G*51F4(K))
                                                                                IMOMTR11
      D_FVAR(1) = DIFVAR(1) + (G*G) *D_F1(K)
                                                                                INOMTR12
      DIFVAR(2) = \overline{\text{DIFVAP}}(2) + (G*G) *DIF2(K)
                                                                                IMOMIR13
      DIFVAR(3)=DIFVAP(3)+(G*G)*DIFT(K)
                                                                                IMOMTR14
      DIFVAR(4) = DIFVAR(4) + (G*4) *D1F4(K)
                                                                                IMOMIR15
31
      DO 32 KK=1.4
                                                                                IMOMTR16
      DIFVAR(KK) =DIFVAR(KK) -(D_FAVE(KK) *DIFAVE(KK))
                                                                                IMOMTR17
      CALCULATE THE ENTROPY, AVERAGE, AND THE VARIANCE OF THE SUM
                                                                                IMOMTR13
                                                                                IMOMTR16
      ARRAY
                                                                                IMOMT921
                                                                                IMONTR?
      no 33 K=1,NOUAN2
                                                                                IMOMTR2:
      IF (SUM1 (K) .LT. 0.000001) GO TO 58
                                                                                INOMIR2
      SUMENT(1) = SUMENT(1) - SUM1(K) *A_OG(SUM1(K))
                                                                                 IMONTR2.
      IF (SUM2(K) -LT. 0.000001) GO TO 59
                                                                                SFTMOMI
 58
      SUMENT(2) = SUMENT(2) + SUM2(K) +ALOG(SUM2(K))
                                                                                IMOMT?2
      IF (SUM3 (K).LT.0.000001) GO TO 60
                                                                                 IMOMTR2
 59
      SUMENT (3) = SUMENT (3) - SUM3 (4) *ALOG(SUM3 (K))
                                                                                IMOMTR2
      IF (SUM4(K) .LT.0.000001) GO TO 61
                                                                                 IMONTR2'
      SUMENT (4) =SUMENT (4) -SUM4 (K) *ALOG(SUM4 (K))
                                                                                 IMOMTR3
                                                                                 IMOMTR3
       CONTINUE
       G=FLOAT(K)
                                                                                 IMOMTR3
                                                REPRODUCIBILITY OF THE
       SUMAVE(1) = SUMAVE(1) + (G*SUM1(K))
                                                                                 IMONTR3
       SUMAVE(2) =SUMAVE(2)+(G*SUM2(K))
                                                ORIGINAL PAGE IS POOR
                                                                                 IMOMTR3
       SUMAVE(3) = SUMAVE(3)+(G*SUM3(K))
                                                                                 IMONT93
       SUMAVE (4) = SUMAVE (4) + (G * SUM4(K))
                                                                                 IMOMTR3
       SUMVAR(1) = SUMVAR(1) + (G+6) #SUM1(K)
                                                                                 IMOMTR3
       SUMVAR(2) = SUMVAR(2) + (6*6) * SUM2(K)
                                                                                 IMOMT23
       SUMVAR(3) = SUMVAR(3) + (G*G)*SUM3(K)
                                                                                 IMOMTRE
       SUMVAR (4) = SUMVAR (4) + (G+G) +SUM4 (K)
                                                                                 IMOMTR4
 33
       DO 34 KK=1,4
                                                                                 IMONTR4
       SUMVAR (KK) = SUMVAR (KK) - (SUMAVE (KK) + SUMAVE (KK))
                                                                                 IMOMTR4
 34
       RETURN
                                                                                 IMONTR4
                                                                                 IMOMTR4
                                                                                 IMONTR4
        SECTION II IMOMTR FOR THE MERGED LEX ARRAY
 C
 C
                                                                                 IMONTR4
        GET THE PROBABILITY FUNCTION IN F FOR MERGE OPTION
                                                                                 IMOMTR4
 C
                                                                                 IMOMTR4
                                                                                 IMONTR4
        DO 16 I=1,NOBL
                                                                                 IMOMTR5
       IA=0
```

			IMOMTR51
	00 17 J=1,NOBL		IMOMTRES
	IN=INDEX(:+1)		IMONTR53
17	IA=IA+LEX1(IJ)		IMOMTR54
16	F(I)=FLOAT(IA)/FLOAT(IR1)		IMOMTR55
C	TOUR MEAN		IMOMT956
C	FIRST COMPUTE THE TRUE MEAN		IMOMT957
C			IMOMT958
	THEAN=0		IMOMTRES
	nn 90 .=1,NOB_		IMOMIRAC
90	THEAN=THEAN+F(I) *FLOAT(I)		IMOMTR61
	THEAN=THEAN+FLOAT (IMIN-1)		IMOMTRES
\$	SET CUMULATIVE DISTRIBUTION	CHNOTION IN F	IMOMTR63
C	SEL COMOCALIAE DIZIKIBOLION	POMOTION THE	IMOMTR64
С			IMOMITAGE
	00 91 I=2,NOBL		IMONTREE
91	F(I) = F(I) + F(I-1)		IMOMTR67
C	THE CHANTER THE CHANTER THE	CATTON	IMOMTRAE
S	CETERMINE THE QUANTIZING FUN	40 LTOM	IMOMTRES
C	TO TO	TANK THE STATE OF	IMONT970
	CALL TERPRIENDEL, NOUANT, F, IO	LUTAL	IMOMTR71
Ç	NEXT COMPUTE THE QUANTIZED	POANSIATED MEAN	IMOMTR72
Č.	NEXT TOWNOTE THE GOANTIZED	KANDER I LO TIERIT	:MOMTR73
C	NONANT		IMOMTR74
	DO 92 I=1,NQUANT		IMOMTR75
	DO 92 J=1, NQUANT		IMOHTR75
	NSI=1	M.	IMOMTR77
	IF (I.NE.1) NSI=IQ(I-1)+2MI		IMOMTR78
	NEI=IQ(1)-IMIN +1		IMONTR79
	NSJ=1	N	IMOMTRBC
	IF (J.NE.1) NSJ=IQ(J-1)+2-IMI		IMONTR81
	NEJ=IQ(J) -IMIN +1		IMOMTPRE
	IF (NSI.GT.NEI) 50 TO 92		IMOMTRAT
	IF (NSJ.GT.NEJ) GO TO 92		IMONTR34
	NADD1=0		IMOMTR85
	DO 93 NI=NSI+NEI		IMOMTR86
	IJ=INDEX(NI,NJ)		IMOMTR87
	NADD1=NADC1+LFX1(IJ)		IMONTRAF
93	AMEAN(3) = AMEAN(3) +FLOAT(NADD	4 # 7 7	IMOMTRES
			IMONTRAC
92	CONTINUE		IMOMTR91
Ģ	NOW NORMALIZE TO GET THE ME	ANS	IMONT992
C	NOW NORMALIZE TO GET THE HE		IMOHTR97
C	AMEAN(3) = AMEAN(3) *R1		IMONTR94
	AUCTUATOL - NUCHULOL - ZT		IMOMT95
Č	NOW DO MOMENT CALCULATIONS		IMONTR96
C	MOM DO MONEMI SACOCATIONS	Control of the second of the s	IMONTR97
C	DO OF THE NOUANT	REPRODUCIHILITY OF THE	IMONTRAR
	DO 95 I=1 NQUANT	REPRODUCIBILITY OF ORIGINAL PAGE IS POOR	IMONTR99
	DO 95 J=1, NQUANT	OPTGINAL PAGE IN TO	INONTRO
	A NSI=1.	Outon.	

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IMONTRUL
      IF (I.NE.1) NSI=IQ(1-1)+2-_MIN
                                                                               SULLHOWI
                 -IMIN +1
      NEI=IQ(I)
                                                                               IMOMIRO3
      NSJ=1
                                                                               IMOMTRO4
      IF (J.NE.1) NSJ=IQ(J-1)+2 -IMIN
                                                                               IMONTR05
                   -_MIN +1
      NEJ=IQ(J)
                                                                               IMONTROS
      IF (NSI.GT.NEI) GO TO 95
                                                                               IMONTRO7
      IF (NSJ.GT.NEJ) GO TO 95
                                                                               IMOMTRO8
      NA001=0
                                                                               IMOMTRO9
      DO 96 NI=NSI.NEI
                                                                               IMOMTR10
      DO 96 NJ=NSJ,NEJ
                                                                               IMOMTR11
      NINJ=INDEX(NI,NJ)
                                                                               IMOMTR12
C
                                                                               IMOMTR13
       SUH UP THE ARRAY
                                                                               IMONTR14
C
                                                                               IMOMTR15
      NADD1=NADD1+LEX1 (NINJ)
96
                                                                               IMOMTR16
C
                                                                               IMOMTR17
       NORMALIZE
C
                                                                               IMONTR18
C
                                                                               IMOMTR19
      RL1=FLOAT (NADD1) *R1
                                                                               IMOMTRER
C
                                                                               IMOMTR21
       COMPUTE MOMENTS
C
                                                                                IMOMTR22
C
                                                                                IMOMTR23
       ANGMOM(3) = ANGMOM(3) + R. 1 + 2
                                                                                IMONTR24
       SGMASQ(3) = SGMASQ(3) + ((FLOAT(I) - AMFAN(3)) **2) * 2L1
       SSMAXY(3) = SGMAXY(3) + (FLOAT(1) - AMEAN(3)) + (FLOAT(J) - AMEAN(3)) + RL1
                                                                                IMOMTR25
                                                                                IMONTR26
       IVOMOM(3) = IVDMOM(3) + RL1/(1.+F.OAT((I-J) **2))
                                                                                IMOMIR27
       IF(RL1.LT.0.000001)GO TO 533
                                                                                IMONTR28
       ENTROP(3) = ENTROP(3) -RL1*4_OG(RL1)
                                                                                IMONTR29
       CONTINUE
                                                                                IMOMTR30
533
                                                                                IMOMT931
C
       SET UP THE SUM ARRAY
C
                                                                                IMOMTR32
C
                                                                                IMONTR 33
       K=IABS(I-J)+1
                                                                                IMOMTR34
                                       RIFRODUCIBILITY OF THE
 C
                                                                                IMOMTR35
       SET UP THE DIFFERENCE ARRAY
                                       SHIGHNAL PAGE IS POOR
                                                                                IMOMTR36
 C
                                                                                IMOMTR37
       KS=IARS(I+J)+1
                                                                                INOMTR38
       DIF3(K) = D1F3(K) +RL1
                                                                                IMOMTR30
       SUM3 (KS) = SUM3 (KS) + RL1
                                                                                IMOMTR40
       CONTINUE
 95
                                                                                IMOMTP41
       RATIO(3)=SGMAXY(3)/SGMASQ(3)
                                                                                IMOMTR42
       CALCULATE THE ENTROPY, AVERAGE, AND THE VAR. ANCE OF THE DIFFERENCE
                                                                                IMOMTR43
 C
                                                                                IMONTR44
       ARRAY
                                                                                IMONTR45
                                                                                INOMTR46
 C
        DO 97 K=1 NOUANT
                                                                                IMOMTR47
        IF (DIF3(K).LT.0.000001) GO TO 577
                                                                                INOMTR4
       DIFFNT(3) = DIFENT(3) - DIF3(K) *ALOG(DIF3(K))
                                                                                 IMOMTR45
 577
        CONTINUE
                                                                                 IHOMTR51
        G=FLOAT (K)
```

	JIFAVE(3) = DIFAVE(3) + (G*D1F3(K))	IMONTRS
97	DIFVAR(3)=DIFVAP(3)+(G*3)*DIF3(K)	IMOMTPS
•	D.FVAR(3)=DTFVAR(3)-(DIFAVE(3)+DIFAVE(3))	IMOMTR5
•		IMOMTR5
ž	CALCULATE THE ENTROPY, AVERAGE, AND THE VARIANCE OF THE SUM	I MOHTRS
ć	ARRAY	I MOMTR5
Č		IMOMTR5
•	DO 98 K=1.NQUAN?	IMOMTR5
	F(SUM3(K).LT.0.000001) GO TO 99	IMONTRS
	SUMENT(3) =SUMENT(3) +SUM3(K) +ALOG(SUM3(K))	IMOMTR6
99	CONTINUE	IMOMTR6
33	G=FLOAT(K)	IMOMTR6
	SUMAVE(3) = SUMAVE(3) + (G*SUM3(K))	IMOMTR6
		IMOMTR6
93	SUMVAR(3) = SUMVAR(3) + (G*G) *SUM3(K)	IMONTR6
	SUMVAR(3) = SUMVAR(3) - (SUMAVE(3) *SUMAVE(3))	I MONTR6
	RETURN COLUMN CO	IMONTR6
	en <b>end</b> en la colonia de la companya de la colonia de la	THUNKO

		en e	
	COD COD		COROGOTI
CCOR	SUPROUTINE COR		CORDOONS
C	THE THE PART CHANNICAM		COR 0 0 0 0 3
Ç	WRITTEN BY SAM SHANMUGAM		COR00014
C		************************	COR 00005
C	****		CORDOD95
C	AD ICOTTUC		COR00007
C	OBJECTIVE.		COR00003
3			CORDODA
C jag	TH.	S PROGRAM CALCULATES THREE MEASURES OF	CORDUUT
C	00	BOCKATION CORTABIRZADUKSA SELMENA ANG	9 - 11 - 1
C	•	PORETE DIANDOM VARIABLES & AND 1. MINUSE	COR00012
C	.10	THE PROBABILITIES OF OCCURANCE ARE	COR00013
C	ST	ORED IN THE ARPAY PXY	COR00014
C			COR00015
С	ENTRY POINT.		COR00016 COR00017
C	ENIKI		
C			COR00018
С	e de la vere de la companya de la c	LL COR(PXY,N,10PT,Q,COR1,COR2,COR3)	COR00020
C			COR00021
0000	INPUT ARGUMENT		COR00021
Ç			COR 80827
C			COR 0 0 0 2 L
Ç	PXY	ARRAY OF JOINT PROBABILITIES	COR00025
C		SIZE OF THE ARRAY PXY	COR0002(
C	IOPT	OPTION FLAGIF IOPT=0 THEN COR1 AND	COR 0 0 0 27
KEPR	ODUCIBILITY OF THE	COR2 ONLY WILL BE COMPUTED. IF IOPT=1, THEN COR3 WILL BE COMPUTED	COR00028
Oktor	MAT DASSITY OF THE	IOPT=1, THEN CORS WILL SE COMPONE	CORODO2°
0	NAL PAGE IS POOR	SCRATCH ARRAY OF SIZE N X N. TH.S. ARRAY IS NEEDED ONLY IF IOPT IS	COR00031
0	- 0010/	TO TANK TO TERM A	COR00031
č		NON-ZERO. IF IOPT IS ZERO THEN A DUMMY VARIABLE MAY BE SUBSTITUTED FOR	COR0003.
Č		DUMMY ANT SE SOBSILIO	COR0003;
č		THE ARGUMENT Q	COR00034
Č			COROUD31
Č	OUTPUT ARGUM	ENTS.	COR00031
Č			COR0003
Č	용 시장 여러에 중소합을 하는 편안된 그 때	MAXIMAL CORRELATION MEASURE	COR0003
CC	COR1	INFORMATION MEASURE OF CORRELATION	SOR 0003
Č	COR 2	SECOND TYPE OF MAXIMAL MEASURE	COR0004
C	COR3	250000 Military	COR0004
Č	그는 시간에 하는 살으로 하늘 3일 번호 보고 있다.		COR0004
C	BIBLIOGRAPHY		COR0004
C		현실 등 등 이 중 현실하다면 하는 이 경기를 보고 있는 수가	COP0004
C	그 이전하다를 그리는 하는 하는 다시다니다.	OF MATHEMATICAL STATISTICS, VO43, 196	2,COR0004
C		* ************************************	The state of the s
C		ELATION AS MEASURE OF DEPENDENCE BY	COR0004
C C C C	La Contraction of the Contractio	BELL.	COR0004
C	하는 것이 하는 것이 하는 하는데, 물로 하는 것은 하는데 그리는 <b>이번 수 있다.</b> 것이라고 있는 사람이 있는 것으로 가장 이번 보는 것이 되는데 되고 있다.	전 " " "	COR0004
C	CAUTTON.	· 발표를 살고 하는데 그들이는 제도하고 Mail 및 등의 등로 보다.	COR 0005
C	The second of the state of the control of the contr	사람이 되는 회사들은 내내는 그 가는 내가 하고 있었다면 생각을 내려 가지 않아 생각이 되는 것이 되었다.	

```
COR 00101
      HX = 0.0
                                                                               COP00102
      HY=0.0
                                                                               COPON103
      HXY=0.0
                                                                               COR00104
      HXY1=0.0
                                                                               CORD0105
      HXY2=0.0
                                                                               COP00106
000
                                  COMPUTE THE MARGINALS AND THEIR ENTROPY
                                                                               COR00107
                                                                               COR00108
                                                                               COR00109
      DO 82 T=1.N
                                                                               COP00110
      00 81 J=1 N
                                                                                COR00111
      IJ=(J-1) *N+I
                                                                                GOR00112
      (LI)YXQ+(I)XQ=(I)XQ
                                                                                COR00113
      IF (PX(I).LT.0.000001) GO TO 82
                                                                                COR00114
      HX=HX=(ALOG(PX(I)))*(PX(L))
                                                                                COR00115
      CONTINUE
 82
                                                                                COP00116
      DO 84 J=1+N
                                                                                COR00117
      DO 83 I=1+N
                                                                                COP00118
      IJ=(J-1)*N+I
                                                                                COR00119
      (LI)YX4+(L)Y9=(L)Y9
 83
                                                                                COR00120
       IF(PY(J)..T.0.000001) GO TO 84
                                                                                COR00121
       (L) Y9* ( (L) Y9) 20 JA- YH= YH
                                                                                COR00122
       CONTINUE
 84
                                                                                COR00123
                                  COMPUTE THE ENTROPY OF THE JOINT DISTR.
                                                                                COR00124
C
                                                                                COP.00125
C
                                                                                COR00125.
       00 69 I=1,N
                                                                                COR00127
       00 69 J=1.N
                                                                                COR 00128
       IJ=(J-1) *N+I
       IF (PXY(IJ).LT.0.000001) GO TO 68 REPRODUCIBILITY OF THE HXY=HXY-(ALOG(PXY(IJ)))*(PXY(IJ)) ORIGINAT DAGE -
                                                                                COR00129
                                                                                COR00130
                                          ORIGINAL PAGE IS POOR
                                                                                COR 00131
       PXPY=PX(I)*PY(J)
                                                                                COR00132
       IF (PXPY. T.0.000001) GO TO 69
                                                                                CORD0133
       HXY1=HXY1-(ALOG(PXPY))*PXY(IJ)
                                                                                COR00134
       HXY2=HXY2-(ALOG(PXPY)) * (PXPY)
                                                                                COR00135
       CONTINUE
  69
                                                                                COR00136
 C
                                                                                COR00137
                                   COMPUTE COR1 AND COR2
 C
                                                                                COR00138
                                                                                COR00139
       EMAX=HX
                                                                                COR00149
       IF (HX.LT.HY) EMAX=HY
                                                                                COR00141
       COR1 = (HXY-HXYI) / EMAX
                                                                                COR00142
       B=HXA5+HXA
                                                                                COR00143
       COR2 = SQRT(1.0-EXP(-2.0*R))
                                                                                COR00144
 C
                                                                                 COR00145
                                   F CORS NOT ASKED FOR RETURN
                                                                                 COR00146
                                                                                 COR00147
       IF (IOPT.EQ. 0) RETURN
                                   SCAN PXY AND DELETE ROWS OF ZEROS
                                                                                 COR 00148
                                                                                 COR 00149
                                   AND COLUMNS OF ZEROS
                                                                                 COR00150
       DO 599 INDFX=1.32
```

```
COR00151
     IZERO (INDEX) = 0
599
                                                                               COR00152
     NZERO =0
                                                                               COR 00 153
     00 600 I=1.N
                                                                               COR00154
     I = I
                                                                               COR00155
     IF(PX(I).GT.0.000001) GO TO 601
                                                                               COR00156
     NZERO=NZERO+1
                                                                               COR00157
     ITERO(NZERO)=II
                                                                               COR00158
601
     CONTINUE
                                                                               COR00159
     CONTINUE
                                                                               COPOU160
     IF (NZERO.EQ.0) GO TO 651
                                                                               COR00161
     1J=0
                                                                               COR00162
     00 650 J=1.N
                                                                               COR 00163
     DO 650 I=1.N
                                                                               COR00164
     DO 640 KK=1,NZERO
                                                                               COR00165
     NDEX=1ZERO(KK)
                                                                               COR00166
      IF ((I.EQ.NDEX).OR. (J.EQ.NDEX)) GO TO 649
                                                                               COP00167
640 CONTINUE
                                                                               COR00168
      1+1/2=1/1
                                                                               COR00169
      I+N*(1-L)=LI
                                                                               COR00170
      (LI)YX9=(LL)YX9
                                                                               COR00171
      CONTINUE
649
                                                                               COR00172
650
      CONTINUE
651
      CONTINUE
                                  REMOVE ZERO ENTRIES IN THE MARSINALS
                                                                               COR00175
      JJ=0
                                                                               COR 00176
      00 661 I=1.N.
                                                                               COR00177
      IF (PX(I).LT.0.000001) GO TO 662
                                                                               COR00178
       JJ=JJ+1
                                                                               COR00179
       \cdot (I) X9=(LL) X9
                                                                               COR00180
                                            REPRODUCTBILITY OF THE GRIGINAL PAGE IS POOR
      CONTINUE
662
                                                                               COR00181
      CONTINUE
 661
                                                                                COR00182
      JJ=0
                                                                                COR00183
       DO 671 I=1.N
                                                                                COR00184
      IF(PY(I).LT.0.000001) GO TO 672
                                                                                COR00185
      JJ=JJ+1
                                                                                COR00186
       (I)Y9=(LL)Ya
                                                                                COR00137
      CONTINUE
 672
                                                                                COR00188
      CONTINUE
 671
                                                                                COR00189
      NNNN=N
                                                                                COR00190
       N=N-NZERO
                                                                                COR 00191
C
                                                                                COR 00192
                                                                                COR00193
CCC
                                  NORMALIZE PXY AND STORE IN Q. SAVE PXY
                                                                                COR00194
                                                                                COR 00195
                                                                                COR00196
       00 58 I=1.N
                                                                                COR00197
       DO 58 J=1.N
                                                                                COR00198
       IJ=(J-1)*N+I
                                                                                COR00190
       CONS=SORT (PY (J))
                                                                                COR00200
       Q(IJ) =PXY(IJ) / CONS
```

```
CORDORNI
C
                                  COMPUTE THE UPPER/OLAG ELEMENTS OF Q*QT
                                                                               COR00202
C
                                                                               COR00203
                                  STORE IN Q
C
                                                                               COR00204
                                                                               COR00205
      00 49 I=1.N
                                                                               COR00200
      00 51 J=I+N
                                                                               COR00207
      B(J) = 0.0
                                                                               CORDOZOR
      00 52 K=1.N
                                                                               COR00209
      IK=(K-1) *11+I
                                                                               COR00213
      JK=(K-1) *N+J
                                                                               COR00211
      9(J)=B(J)+Q(IK)*Q(JK)
 52
                                                                               COR00212
      CONTINUE
                                                                               COR 00213
      03 50 J=1.N
                                                                               COR00214
      IJ = (J-1) + N + I
                                                                               COR00215
      Q(IJ) =B(J)
 50
                                                                               COR00216
       CONTINUE
 49
                                                                               COR00217
C
                                                                               30R00218
                                  FILL IN THE BELOW DIAG ELEMENTS OF Q*QT
C
                                                                               COR00219
C
                                                                               COR00220
       00 48 J=1.N
                                                                               COR00221
       DO 48 I=J.N
                                                                               COP00222
       IJ=(J-1) +N+I
                                                                                COR00223
       J = (I-1) *N+J
                                                                                COR00224
       Q(IJ) = Q(JI)
 48
                                                                                COR00225
                                  FORM SQRT(PX) + Q+QT + SQRT(PY)
ø
                                                                                COR00225
                                  STORE IN Q
CC
                                                                                COR00227
       00 91 I=1.N
                                                                                COR00228
       DO 91 J=1.N
                                                                               COR00229
       IJ=(J-1) *N+I
                                                                                COR 00230
       Q(IJ) = Q(IJ) \times (SQRT(PX(I) *PX(J)))
 91
                                                                                COR00231
C
                                  GET THE EIGEN VECTORS AND EIGEN VALUES
                                                                                COR00232
C
                                                                                COR00233
                                  OF Q*QT
C
                                                                                COR00234
                                                                                COR00235
                                  CALL THE SUBPOUTINE TO GET THE EIGENVALS COROD236
                                   GET A MAX OF 5 EIGENVALUES. IF ALL FIVE COROO237
 C
                                   ARE NEAR UNITY, SET COR3=1.9999. RETURN
 C
                                   IF ALL OF THEM (OTHER THAN THE FIRST ONE) COPO0235
 C
                                   ARE LESS THAN 0.001 . SET 3023=0.0001 ANDSOR00240
 C
                                   RETURN. THE FIGEN VALUES ARE CALCULATED
                                                                                COR00241
 C
                                                                                SOR00242
                                   WITH AN ACCURACY OF 0.0001.
 C
                                                                                COR00243
                                                                                COR00244
                                                                                SOR00245
       MAX=5
                                                                                COR00246
       IF (N.LT.MAX) MAX=N
                                                                                COR00247
       GR = 0 . 0001
                                                                                COR00240
       EPS=0.00001
                                                                                COR 00249
        CALL SEAD2D(Q, N, N, CR, EPS, MAX, NE, E, V, B, C, D, F, IE)
                                                                                COR00250
 C
```

CIE	gPQ1	I-E-0-P-		IEOPO101
C			SEPT 1971	IFGPQ193
C	V	RITTEN 3Y DENISH GOEL		IEQPQ104
C				IEOPO105
C	ū	FSCRIPTION OF PROGRAM.	K LEVELS OF QUANTIZING FOR AN ARRAY	IEOPQ106
C	1	HIS SUBROUTINE DETERMINES	ISTRIBUTION FUNCTION OF ALL THE EL-	IEGPQ107
C	F	OR WHICH THE CUMMULATIVE D	ATMED	IEQPQ108
C	ł	IENTS HAVE ALREADY BEEN OUT	ALYCO.	IEQPQ109
C				IFOPO110
C				IEOPQ111
C	1	ENTRY POINT.	MTNI	IEOPQ112
C		CALL IEGPO1 (N.K.F. IQ. I	MALTY.	IEOPO113
C				IEOPO114
C		ARGUMENTS.		IEQPQ115
C			NUMBER OF ITEMS TO BE QUANTIZED, THE	IEOPQ116
C			DIMENSION OF THE F ARRAY.	IEQP0117
C		and the second of the second o	- OF OUR NETTTING I EVELS	TEQPQ118
C		Ķ	THE NUMBER OF QUANTIZING EDISTRIBUTION INPUT ARRAY OF CUMULATIVE DISTRIBUTION	ONTEGAÜTIA
C,			CINCTION	
C			OUTPUT ARRAY OF QUANTIZING LEVELS.	IEOPQ121
င		IQ.	THE LOWEST POSSIBLE LEVEL IN	IEQPQ122
C		imin' di la	THE INPUT DATA.	IEQPQ123
C				IEOPO124
C				IEOPO125
C		SUBROUTINE IERPRINK, F.IR	• I M) (N)	IEQPQ126
		SOBSOOLINE TERESTAMENT ATT		IEOPQ127 IEQPQ123
C		DIMENSION F(1), IQ(1)		IEQPQ129
				IEQPQ130
		DIF=10.**6		IEQPQ131
C		OSTAIN THE FIRST QUANTIZIN	G LEVEL.	IEQPQ132
C		GO THRU THE WHOLE ARRAY OF	C.D.F,S	IEQPQ133
C		GO THE MASE THE		IEQPQ134
C		00 1 J=1.N		IEQPQ135
		DO 1 9-144	ALTERNATION OF A SHELL AND	IEOPO136
Č		STAD DEPCENTAGE OF DISTRIC	BUTION FOR FIRST QUANTIZING LEVEL AND	IEOPQ137
Ç		CHECK FOR THE NEAREST C.J.	( <b>F.</b> 이 10) 등한 기계 전환 기계 시간 사용 전환 시험한 기업이	IEQPQ138
C		CHECK FOR THE WAY	이 경기 이 속이 많으로 가는 일이 되지만 나라고 하는데 하는데 하는데 다른데 다른데 되었다.	IEOPQ139
C		X=A3S(1./FLOAT(K)-F(J))		IEGPQ140
		IF (DIF.LE.X) GO TO 1		IEOPO141
		DIF=X	그는 사람들이 마시되고 받는데 그들에 그리워 하는 목모에 다른	IEQPQ142
		ISAVE=J		IEQPQ143
	1			IEQPQ144
C	<del>-</del> -	of Wildian Control of the Control of the	보고 있다. 한 시간 하노네는 그런 그리는 이 이 경기를 모르겠다.	IEQPQ145
Č		FIRST QUANTIZING LEVEL	물의 학생들은 것으로 발표하는 생활 작곡을 발표하는 보기로 보고 있었다.	TEQPQ146
C		그가 있으면 하는 것이 그렇게 많이 있었다면 그래?	발생하는 말 없는 말통을 걸 때문에서 이렇게 함께 없는 때문에 있다.	#FQPQ147
		IQ(1)=ISAVE+IHIN-1	어느 경우 역사 회사에 한 경우는 눈이 있는데 전통 중요는 공연 회원을 받았다.	IEOPQ148
C		아이 있는 말을 하고 있는 사고 있다고 있는 지역에 살았다.	요즘은 글이다가 많은 아이지를 하는 것으로 그렇게 되었다.	IEOP7149
Č		TO GO FOR NEXT LEVEL		IEQPQ150
Č		얼마, 아마스 등 이번 그리고 나는 아마스다.	있다는 경기가 되는 경기를 보고 하는 사람들이 다음을 내고 있다.	

		IEOPO151
	LFTOFF=ISAVE	IEQPQ152
	00 2 I=2,K	IEOPQ153
C	THE STATE ARE STATE OF THE STAT	IEOPQ154
C	DECIDE FOR OTHER QUANTIZING LEVELS IN THE SIMILAR WAY.	IEOPQ155
C		IEQPQ156
	DIF=19•**6	IEQPQ157
	30 3 J=LFTOFF.N	IEGPQ158
C	THE PERCENTAGE OF DISTRIBUTION FOR NEXT QUANTIZING LEVEL WILL	IE0P0159
C	THE PERCENTAGE OF SISTEMENTS	IEQPQ160
Ç.	BE DECIDED AMONG REST OF ELEMENTS.	IEOPQ161
C	X=ABS(((1F(LFTOFF))/FLOAT(K-I+1))+F(LFTOFF)-F(J))	IEUPQ162
	X=ABS(((1+(CFI)))))	IEGPQ163
	IF (DIF LE.X) GO TO 3	IEQPQ164
	DIF=X	IECPQ165
	ISAVE=J	IEQPQ156
Ğ	GET THE NEXT QUANTIZING LEVEL	IEQPQ167
C	GET THE NEXT HUMBITZING ECOLO	IEQPQ168
C	<u> Barana kanna araba da karangan kanangan kanangan kanangan kanangan kanangan kanangan kanangan kanangan kanang</u>	IEQPQ169
	3 CONTINUE IQ(I)=ISAVE+IMIN+1	IEQPQ170
		IEOPQ171
	LFTOFF=ISAVE	IEQPQ172
	2 CONTINUE	IEQPQ173
	RETURN	IEQPQ174

4.5.5.4.4.5		R-I-T-0-W-T	JJNE 1973	RITOWT01
CRITOHT ,		K-1-1-00 W		RITOWT12
C			SEPT 1971	RITOHT03
C WRITTEN BY RMH		TARE OUTRIT OPTION	NOV 1972	4CTWOTIS
	J BOSLEY FOR	TAPE OUTPUT OPTION	JUNE 1973	RITONTOS
C VERSION 2 BY R	A ROPLEA LOK	nt,Kut	55 VL 17. 5	RITOWTOS
C				RITONT07
C OF DESCRIPTION OF	PROGRAM.	THE OR HOTTER TO ETTEL	TEN THE TEXTURE	RITOWTOS
C THIS SUBROUTIN	IE PUNCHES, PR	INTS OR WRITES TO FILE!	IF, TE TEXTORE	RITONTO9
C " CATA ACCORDIN	IS TO THE PAU	H / MERGE OPTIONS		RITOWTLD
C CATA ACCORDING C ENTRY POINT.			* •	RITOWTIL
C ENTRY POINT.		The same of the Mener Men	CE TE ST. TUS	RITOWT12
C CALL RITOWT	(LEX1,LEX2,L	EX3, LEX4, G, 1Q, MERGE, MER	GE + IF + FIJ TOKY	RITOWT13
C		$\frac{K}{2}$	Lot on the	RITOWT14
C ARGUMENTS.		ka <sup>n</sup> kumu basene at <b>u u</b> n	E . EV ADDAMC	RITOWT15
C LEX1-L	EX4	ADDRESS INDEXS FOR TH	E LEX ARRAYS	RITOWT15
C		COF FOR THE IMAGE DAT	A SE NOUTHE	;
C		QUANTIZED OUTPUT OF I	EDPOI OF NOUANI	RITOWT17
C		LEVELS		RITOWT18
C MERGE		OPTION TO MERGE THE F	OUR LEX ARRAYS	RITOWT19
C		INTO ONE ARRAY		RITOWT20
C		FILE CODE FOR OUTPUT	TAPE	RITOHT21
C PICTU	₹	OPTION TO PRINT A PIG	TURE OF THE	RI TOWT 22
OC 10 10 11 11 11 11 11 11 11 11 11 11 11		IMAGE, USED TO VA	RY SPACING	RITOWT23
Č			A Company	RITONT24
C INTERNAL PARAL	METERS.			RITOWT25
C PNCH		=TAPE FOR TAPE OUTPUT	ON FALE IF	SILON150
C PNCH		=Y FOR PUNCH OUTPUT		RITOWT27
c PNCH		EN FOR PRINTER OUTPU	JT ONLY	<b>RITOHT28</b>
C NPED		REDUCTION FACTOR FROM	1 FPLXIT	RITOHT29
C NLAYE	D	THE POWER TO WHICH N	RED IS RAISED	RITOWT30
C NFT	N.	AMOUNT OF REDUCTION	IN FPLXIT	RITOWT31
		THE NUMBER OF ANGLES	USED IN LEX	RITOWT32
<u>C</u>		ARRAYS		RITOWT33
C PNCH NPED C NLAYE C NFT C N		THE LEX ARRAY CONTAIN	NING A THE	RITOWT34
C M		MERGED ARRAYS		RITOWT35
- <b>C</b>		IMAGE ROW INDEX		RITOWT36
C M1		IMAGE COLUMN INDEX	Born John College Branch	RITOWT37
C N1		CARD COUNTER		RITOWT 38
C	and the second s	FEATURES		RITOWT39
9	MCORMAX	NUMBER OF BRIGHTNESS	FVF S IN IMAGE	RITOWT40
C NOBL		LINE COUNTER FOR MER	GE OPITON	RITOHT41
C		ETHE GROWLEY LOW HEY		RITOHT42
		X2, LEX3, LEX4, G, IQ, MERGE	TE-POTUR)	RITOWT43
	TOWN (LEXI)CE	XZ . EEX3 . EX4 . G . I I I I I I I I I I I I I I I I I		RITOWT 44
- 40 <b>0</b>	المعالمين المتابية	LEXT(1), LEX4(1), G(64),	70(64).3(4)	R TOWT45
DIMENSION LEX	1(1), LEX2(1)	*FEX. (II. ) FEX. (II. ) ARE VALLE	1.968493(4).	RITOWT46
COMMON M1,N1,	TYPF.F(14),1	JO(9), ANGMOM(4), AMEAN(4	ACT1 NOFT	RITOWT47
1 SGMAXY(4),DI	FMOM(4),RATI	D(4), VIDMON(4), THEAN. LE	AJI 4 10 NEV	RITONT48
COMMON N_AYF	R.NSTART.NT	MES, NU, P'NUM	AL SUMENTIAL.	RITOWT49
COMMON /E_/EN	TROP(4), CIFE	NT(4).DIFAVE(4).DIFVAR(	41,3000,01141,	RITOWT50
1SUMAVE (4) , SUM	IVAR (4)			

```
RITOHT51
     COMMON /CORREL/CORINF (4) .CORMUT (4) .CORMAX (4)
                                                                             RITOWT52
     LOGICAL MERGE, PICTUR
                                                                             RITOHT53
     DATA B(1),B(2),B(3),B(4)/0.,45.,90.,135./
                                                                             RITOWT 54
                                                                             RITOHT55
     DATA TAPE/1HT/
                                                                             RITOWT56
      DATA Y/1HY/
      DATA KOUNT/0/.IMT/0/
                                                                             RITOWT57
      NFT=NRED ** NLAYER
                                                                             RITOWT58
                                                                              RITOHTSE
      N=4
                                                                              RITOWT60
      KKJ=50
                                                                              RITONT61
      M = 3
                                                                              RITOWT62
C
                                      REPRODUCIBILITY OF THE
      CHECK FOR THE MERGE OPTION
                                                                              RITOWT63
C
                                      ORIGINAL PAGE IS POOR
                                                                              RITOWT54
C
      IF (MERGE) GO TO 22
                                                                              RITOWT65
                                                                              RITOWTER
                                                                              RITOWT67
       PUNCH OR NO PUNCH
                                                                              RITOWT68
C
      IF (PNCH.NE.Y) GO TO 400
                                                                              RITOWT60
                                                                              RITOWT70
C
       PUNCH TEXTURE FEATURES FOR ALL FOUR ANGLES
                                                                              RITOWT71
C
                                                                              RITOWT72
       WRITE(43,60) M1,N1,NFT
                                                                              RITOWT73
  106 FORMAT(1X, 2A5, 12HIS COMPLETED)
                                                                              RITOWT74
                                                                              RITOWT75
       KOUNT=KOUNT+1
       WRITE(43,600 ) (ANGMOM(K), K=1,4), (ENTROP(K), K=1,4), KOUNT
                                                                              RITOWT76
                                                                              RITOWT77
       WRITE(43,600) (RATIO(K),K=1,4),(SGMASQ(K),K=1,4),KOUNT
       KOUNT=KOUNT+1
                                                                               RITOWT78
                                                                               RITOWT74
       KOUNT=KOUNT+1
                      (SGMAXY(K), K=1,4), (AMEAN(K), K=1,4), KOUNT
                                                                               RITONTEC
       WRITE (43,600)
       KOUNT=KOUNT+1
                                                                               RITOWT81
       WRITE (43,600) (VIDMOM(K), K=1,4), (TMEAN, K=1,4), KOUNT
                                                                               RITOWT82
                                                                               RITOWT83
       KOUNT=KOUNT+1
       WRITE (43,600) (DIFENT (K), K=1,4), (DIFAVE (K), K=1,4), KOUNT
                                                                               RITOWT81
                                                                               RITOWTHE
       WRITE (43,600) (DIFVAR(K), K=1,4), (SUMENT(K), K=1,4), KOUNT
                                                                               RITOWTSE
       KOUNT=KOUNT+1
       WRITE (43,600) (SUMAVE(K), K=1,4), (SUMVAR(K), K=1,4), KOUNT
                                                                               RITOWT87
                                                                               RITONT8'
                                                                               RITOWT8'
       KOUNT=KOUNT+1
       HRITE (43,600) (CORINF (K), K=1,4), (CORMUT (K), K=1,4), KOUNT
                                                                               RITOWT9
                                                                               RITOWT9'
        KOUNT=KOUNT+1
        WRITE (43, 601) (CORMAX (K), K=1,4), KOUNT
                                                                               RITOWT9'
   600 FORMAT (1X,8F9.5,17)
                                                                               RITOWT9
       FORMAT(1X,4F9,4,38X,15)
                                                                               RITOWT9:
  601
        FORMAT(1X, 4F9.5, 36X, 17)
                                                                                RITOWT9
 661
                                                                                RITONT9
    400 CONTINUE
                                                                                RITOWT9
         WRITE TEXTURE FEATURES TO TAPE FILE "IF"
 C
                                                                                RITOWT9
 :
                                                                                RITOWT9
  C
        IF (PNCH. NE. TAPE) GO TO 500
        HRITE(IF) M1, N1, NFT, (ANSMOM(K), K=1,N), (ENTROP(K), K=1,N), (RATIO(K), RITOWTO
```

```
1K=1,N), (SGMASQ(K),K=1,N), (SGMAXY(K),K=1,N), (AMEAN(K),K=1,N),
                                                                            RITOWTOL
                                                                            RITOWT02
     1(VIOMOM(K),K=1,N),(TMFAN,K=1,N),(OIFENT(K),K=1,N).
                                                                            RITOWTOS
     140 IF AVE(K), K=1,N), (DIFVAR(K), K=1,N), (SUMENT(K), K=1,N),
     1(SUMA VE (K), K=1,N). (SUMVAR(K), K=1,N). (CORINF(K), K=1,N). (CORMUT(K).
                                                                           RITOHT04
                                                                            RITOHTOS
     1K=1.N), (CORMAX (K),K=1,N)
                                                                            RITOWT 06
  508 CONTINUE
                                                                            RITOWTO7
       PRINT TEXTURE FEATURES FOR EACH ANGLE AND TITLE
                                                                            RITOWTOB
C
                                                                            RITOWT09
C
                                                                            RITOWT10
      WRITE(6.60) M1.N1.NFT
   60 FORMAT(/ THE SCENE (', 12, ', 12, ') HAS BEEN REDUCED BY ', 15)
                                                                            RITOWT11
                                                                            RTTOWT12
       WRITE(6,303)
      FORMATIOH ANGLE ,9H ANGMOM ,8H ENTROP ,8H RATIO ,84 SGMASO
                                                                            RITOWT13
     18H SGMAXY ,8H IVDMOM ,8H WIFFNT ,8H DIFAVE ,8H DIFVAR ,8H SUMENT ,RITOWT14
                                                                            RITOWT15
     18H SUMAVE ,8H SUMVAR ,8H CORINF ,7HCOPMUT ,8H CORMAX )
      WRITE(6,300)(8(K),ANGMOM(K),ENTROP(K),RATLO(K),SGMASQ(K),SGMAXY(K)RITOWT16
     1, VIDMOM(K), DIFERT(K), CIFAVE(K), DIFVAR(K), SUMENT(K), SUMAVE(K),
                                                                            RITOWT17
                                                                            RITOWT18
     ?SUMVAR(K), CORINF(K), CORMUT(K), CORMAX(K), K=1, N)
                                                                            RITOWT19
 300 FORMAT(1X.F5.1.15F8.4)
                                                                            RITOWT20
      WRITE(6,600) TMEAN
                                                                            RITOWT21
      CONTINUE
  100
                                                                            RITONT22
C
                                                                            RITOWT23
       IF NEITHER PNCH NOR TAPE, PRINT LEX ARRAYS
                                                                            RITOWT?4
                                                                            RITOWT25
      IF ((PNCH.EQ.Y) .OR. (PNCH.EQ.TAPE)) RETURN
                                                                            RITOWT26
      WRITE (6,30) G
                                                                            RITOWT27
      WPITE(6,31) IQ
                                                                            RITOWT28
   30 FORMAT(2H F/(1X.16F7.3))
                                                                            RITOWT29
    31 FORMAT(3H IQ/(1X,1617))
                                                                            RITOWT30
      NOBL=IDD(1)-IDD(2)+1
                                                                            RITOWT31
                                                                            RITOHT32
       IF MERGE, JUST DO LEXI AND RETURN
                                                                            RITOWT33
C
                                                                            RITOWT34
      IF (MERGE) SO TO 54
                                                                            RITOWT35
      WRITE (6,566)
                                                                             RITOWT35
  566 FORMAT(//10X,9HO DEGREES)
                                         REPRODUCIBILITY OF THE
                                                                             RITOWT37
       no 58 i=1.NOBL
                                         ORIGINAL PAGE IS POOR
                                                                             RITOWT38
      NS=1*(I-1)/2+1
                                                                             RITOWT39
      NE# (I+1) *7/2
                                                                             RITOWT40
                                                                             RITOWT41
        PRINT LEX2 FOR 0 DEGREES
Ċ
                                                                             RITOWT42
                                                                             RITONT 43
    50 HRITE (6,700) (LFX2(J),J=NS,NE)
                                                                             RITOWT 44
   700 FORMAT(1X,2615)
                                                                             RITOWT45
       WRITE (6,567)
                                                                             RITOWT46
   567 FORMAT (//10X.10H45 DEGREES)
                                                                             RITOWI47
       DD 51 I=1,NOBL
                                                                             RITOWT48
       NS=1+(I-1)/2+1
                                                                             RITOWT49
       NE=(1+1)+1/2
                                                                             RITOWT50
 C
```

```
RITOWT51
       PRINT LEX4 FOR 45 DEGREES
                                                                           RITOWT52
¢
                                                                           RITOWT53
   51 WRITE(6.700) (LEX4(J),J=NS.HE)
                                                                           RITOWIS4
                                                                            RITOWT55
      WRITE (6.99)
                                                                            RITOWT56
   99 FORMAT (111)
                                                                            RITOWT57
      WRITE (6,568)
  568 FORMAT (//19X,10490 DEGREES)
                                                                            RITONT58
                                                                            RITOWT59
      on 52 .=1.NOBL
                                                                            QITOWTHO
      NS=I+(1-1)/2+1
                                                                            RITOWT61
      NE = (I+1) + 1/2
                                                                            RITOWT62
       PRINT LEX1 FOR 90 DEGREES
                                                                            RITOHT63
C
                                                                            RITOWT64
Ċ
   52 WRITE(6,700) (LEX1(J).J=NS.NE)
                                                                            RITONT65
                                                                            RITOWTER
       IF (MERGE) RETURN
                                                                            RITOWT67
       WRITE(6,569)
  569 FORMAT (//10X,114135 DEGREFS)
                                                                            RITOWT6P
                                                                            RITOWT69
       00 53 I=1, NOBL
                                                                            RITOWT76
       NS=I*(I-1)/2+1
                                                                            RITOWT71
       NF=(I+1) *1/2
                                                                            RITOWT72
 C
        PRINT LEX3 FOR 135 DEGREES
                                                                             RITOWT73
                                                                             RITOWT7"
    53 WRITE(6.700) (LFX3(J),J=NS,NE)
                                                                             RITOWT75
                                                                             RI TOWT 78
        RETURN
                                                                             RITOWT77
 C
        RITOWT FOR THE MERGE OPTION
                                                                             RITONT76
 C
                                                                             RITONT7º
        CHECK TO SEE IF A PICTURE HAS BEEN PRINTED
 C
                                                                             RITONTS!
 C
                                                                             RITOWT 81
 C
        IF (PICTUR) GO TO 23
                                                                             RITOWT 81
 22
                                                                             RITOWT8
 C
                                                                             RITOWT84
         INCREMENT PAGE COUNT
 C
                                                                             RITOWT85
  C
                                                                             RITOWTS
        IHT=IHT+1
                                                                             RITOWTS
         IF PAGE IS FULL GO TO TOP OF NEXT PAGE AND WRITE TITLE
  C
                                                                             RITOWT8
  C
                                                                             RITOWTS
        #F (IMT._E.1) WRITE (6,662)
                                                                              RITOWTS
                                                                              RITOWT9
        IF (IMT.GE.14) IMT=0
        FORMAT(1H1,40X, ERTS TEXTURE ANALYSIS 1/
                                                                SSMAXY EVOMORITOWT9
                                               RATIO SGMASQ
  662
                   1X. ANGLE ANGMOM ENTROP
       1M DIFENT DIFAVE DIFVAR SUMENT SUMAVE SUMVAR COPINE CORMUT RITOWT9
                                                                              RITOWT9
       1 CORMAX '/
                                                                              RITOWTS
                                                                              RITOWT9
          CHECK FOR PUNCH
                                                                              RITOWT9
                                                                              RITOHT9
         IF (PNCH.NE.Y) GO TO 40
   23
                                                                              RITOWIO
          PUNCH THE MERGED TEXTURE FEATURES
                                              REPRODUCIBILITY OF THE
                                              ORIGINAL PAGE IS POOR
```

```
RITOWINI.
      HRITE (43.663) MI, NI, NET, ANGMOM (M), ENTROP(M), RATIO(M), SSMASQ(M),
                                                                               RITOWINZ
C
                                                                               RITOHTOS
     1 SGMAXY(M), AMEAN(M), VIDMOM(M), KOUNT
                                                                               RITOWT04
                        THEAN, DIFENT (M) . DIFAVE (M) . DIFVAR (M) . SUMENT (M) .
                                                                               RITOWT05
      KOUNT = KOUNT +1
      WRITE (43,664)
                                                                               RITOWT06
     1 SUMAVE (M) . SUMVAR (M) . KOUNT
                                                                               RITOWT07
                                                                                RITOWT08
       KOUNT=KOUNT+1
       WRITE (43,665) CORINF (M) + CORMUT (M) + CORMAX (M) + KOUNT
                                                                                RITOWT09
       KOUNT=KOUNT+1
                                                                                RITOWT 10
       FORMAT(12.14,12,12,1X,7F9.5,59)
                                                                                RITOWT11
663
       FORMAT(8X+7F9.5+19)
                                                                                RITOWT12
664
       FORMAT(8X,3F9.5,36X,19)
                                                                                RITOWT13
665
                                                                                RITOWT14
       CONTINUE
40
        SHECK FOR TAPE OUTPUT
                                                                                RI TOWT 15
       IF (PNCH.NE.TAPE) GO TO 41
                                                                                RITOWTIE
                                                                                RITOWT17
        WRITE OUT ONTO FILE "IF" THE MERGED TEXTURE FEATURES
C
                                                                                RITOWT18
C
       WRITE(IF) M1,N1,NFT,ANGMOM(M),ENTROP(M),RATIO(M),SGHASQ(M),
                                                                                RITOWT19
 C
      1 SGMAXY(M), AMFAN(M), VIDMOM(M), TMEAN, DIFENT(M), DIFAVE(M),
                                                                                RITOWT20
      2 DIEVAP(M), SUMENT(M), SUMAVE(M), SUMVAR(M), CORINE(M), CORMUT(M),
                                                                                RITOWT21
                                                                                 RITOWT 27
      3 CORMAX(M)
                                                                                RITOWT23
        IN ANY CASE, PRINT THE MERGED TEXTURE FEATURES
                                                                                 RITOWT21
 C
                                                                                 RITOWTES
 C
                                                                                 RI TOWT 26
 C
                           ANGMOM(M), ENTROP(M), RATIO(M), SGMASQ(M), SGMAXY(M) RITOWT2
       WRITE(6,60) M1,N1,N=T
       1, VIUMOM(M), DIFENT(M), DIFAVE(M), DIFVAR(M), SUMENT(M), SUMAVE(M),
                                                                                 RITONTE
                                                                                 RI TOWT 2'
       2SJMVAR(M), CORINF (M), CORMUT(M), CORMAX(M)
                                                                                 RITOWT3[
        FORMAT (1X, "MERGE", 15F8.4)
                                                                                 RITOWT3
 666
        WRITE (6,667) THEAN
                                                                                 RITOWT3:
        FORMAT(1X, F9.5/)
                                                                                 RITOWT3
 667
                                                                                 RITOWT3/
         NOW GO PRINT OUT THE MERGED LEXT ARRAY AND RETURN
 Ç
                                                                                 RITOWT3
  C
                                                                                 RITOWT3
  C
                                                                                 RITOHT3
        GO TO 100
         END
```

# IV.2-c Cross-Band Texture Analysis Program Listings

SPECTR

GETIM / GETIT

ERTS (see IV.2-a)

DIFFER

COVAR

MNCVIN / MNCV

CORREL

CTR	CROSS-RAND	TEXTURE ANALYSIS	SPECTRO1
		JAN 1974	SPECTP03
WRITTEN BY	RJ BOSLEY		SPECTR04
			SPECTROS
DESCRIPTI	ON OF PROGRAM	THE DESCRIPTION A STATE A	SPECTROS
THIS P	OGRAM IS THE	MAINLINE OF PROGRAMS WHICH OSTAIN A	SPECTR07
			SPECTROS
EACH SUBI	MAGE CALCULATES	SUBTRACE RATRIX AND THE	SPECTROS
CORRELATI	ON MATRIX. TH	72 MHIKTY TO WATER	SPECTR10
FURTHER A	HALYSIS.	CESSED IN HORIZONTAL ROWS OF SUBIMAGES.	SPECTR1
THE ER	TS TAPE IS PRO	CESSEU IN HORIZONTAL MAND THE	SPECTP1
SUBIMAGES	MAY OVERLAP H	ORIZONTALLY AND VERTICALLY, AND THE	SPECTR1
DISTANCE	PETWEEN NEIGHS	ORING CELLS USED IN THE DIFFERENCE ARRAY	SPECTR1
IS VARIAB	LE.		SPECTR1
			SPECTRI
NOTE			SPECTRI
ERTS INPU	T TAPE MUST BE	EQUIRED ON FILE 11 3 FILE 11, A11R, 30R	SPECTRI
A RANDOM	DISC FILE IS R	SEGULKED ON LICE ITTEL TO SEE THE SECULIAR SECUL	SPECTRI
			SPECTR2
INTERNAL	PARAMETERS	NUMBER OF GREY TONE N-TUPLE SOMP.	SPECTRE
	NOIM	NUMBER OF LINES IN A SUBINAGE	SPECTR2
	NUMLIN	NUMBER OF COLUMNS IN A SUPINAGE	SPECTR2
	NUMPPL	ROW COORD FOR THE SUBINAGE	SPECTR
	NROW	COLUMN COORD FOR THE SUBIMAGE	SPECTRA
	NCOL	DISTANCE BETHEEN NELGHBORING RES.	SPEUTRA
	IDIST	CELLS FOR THE DIFFERENCE IMAGE	SPECTRA
		STARTING ROW FOR THIS RUN	SPECTRA
In the state of	CRSTRT	GEODENIC BOW FOR THIS RUN	SPECTRA
	IRSTOP	SET=0. THE STRIP WILL BE PROJESSED	SPECTR
e en la Sangraga 😼		TO TTO FNO OF FILE	SPECTR
		HORIZONTAL OVERLAP OF SUBINAGES	SPECTR
	LAPHOR	VEDITI AL OVER AP OF SUBIMAGES	SPECTR
	LAPVER	NUMBER OF OVERLAPING HORIZONTAL	SPECTR
	NHOR		SPECTR
		ENDING POINT FOR ONE LINE FROM ERIS	SPECTR
	IPEND	ETMA. POW OF SUREMAULD	SPECTR
	LASTIM	CORRE ATION COVAR ANDE MATRICES	SPECTR
	COR, COV	TITLE FOR THE MATRIX	SPECIA
	TTL		the state of the s
	TITLE	FORMAT FOR DO NT NG OUT MAIRIX IERNS	
and a second of the second of	FMT	THE THE TAX POST OF THE PROPERTY OF THE PROPER	SPECTS
	OPT	DETERMINES OUTPUT FILE FOR LEATURES	SPECIF
	PNCH	TOUCHOU ET L'ASSELIN DEU MANGO	SPECTR
		EALSE FOR FILE 81. APE UK ULDU	SPECTO
		LANGE OF THE COUNTRY	
	. F	MANUAND COL NAMES FOR MATCA A FRANCISCO	
	LABEL	DETERMINANT OF THE CURRELA LOW	SPECTA
	OET ENTROP	ENTROPY MEASURE	SPECT
	CHIKUL	CARD COUNTER	SPECT
	KT	CARO COVIVICIO	CDALLA

```
CROSS-BAND TEXTURE ANALYSIS
12-12-74
           18.629
                                                                                      SPECTR5
        INPUT ARGUMENTS.
 C
                                                                                      SPECTRS
                                      ARRAY CONTAINING SUBIMAGE
                  TMAGE . X
 C
                                      ARRAY FOR READING ERTS TAPE
                                                                                      SPEC TR5
 C
                  ILINE
                                                                                      SPECTES
                                      ROW DIMENSION OF IMAGE
 C
                  LYDIM
                                                                                      SPECIAS
                                      COL DIMENSION OF IMAGE
                  IXDIM
 C
                                                                                      SPECTRE
                                       EQUAL TO NOIM. NO OF BANDS
 C
                  NOIN
                                                                                      SPEJ TR5
 C
                                                                                      SPECTP6
 C
        ENTRY POINT.
                                                                                      SPECTRS
                  CALL SPECTR (IMAGE, X, ILINE, IXDIM, IYDIM, NOIN)
                                                                                      SPECTR6
 Č
                                                                                      SPECTRE
           EXAMPLE OF DRIVER.
                                                                                      SPECTR6
                  UIMENSION IMAGE(16,17,4),X(16,17,4),ILINE(3301)
 C
                                                                                      SPECTP6
                  EQUIVALENCE (IMAGE (1.1.1), X(1.1.1), ILINE (130))
                                                                                       SPECTR6
                  _XDIM=17
  Ċ
                                                                                       SPECTP6
                  YDIM=16
 C
                                                                                       SPECTOS
 Ċ
                  NOIM=4
                                                                                       SPECTR6
                  CALL SPECTRE (IMAGE, X, ILINE, IXDIM, IYDIM, NOIM)
  C
                                                                                       SPECTR7
  C
                  STOP
                                                                                       SPECT97
  Č
                  END
                                                                                       SPECTR7
  C
          THIS PROGRAM WILL SET UP THE TEXTUR RUN FOR 16 X 16 SUBIMAGES
                                                                                       SPECTR7
  C
                                                                                       SPECTR7
                                               ***NOTE***IXDIM MUST INCLUDE
        OVER ALL FOUR BANDS, WITH IDIST=1.
  C
        NUMPPL PLUS IDIST, AND ARRAY ILINE MUST HAVE AT LEAST NUMPPL*NDIM
                                                                                       SPECTR7
        POINTS OUTSIDE OF ANY OTHER ARRAY. THESE POINTS FORM ARRAY XLINE
                                                                                       SPECTR7
                                                                                       SPECITR7
        WHICH IS USED IN COVAR TO SEND ONE LINE OF DATA TO MNOV.
                                                                                       SPECIP7
  C
                                                                                       SPECIF?"
        SUBPROGRAMS REQUIRED.
  C
                                                                                       SPECTR8
          DRIVER
  C
                                                                                       SPECTRE
  C
             SPECTR
                                                                                       SPECTR81
               GETIM
                                                                                       SPECTR8
  C
               SETDIM
                                                                                       SPECTR8/
  Ċ
               GETIT
                                                                                       SPECTR8!
                 ERTS (WITH EREWND)
  C
                                                                                       SPECTR86
               DIFFER
  C
                                                                                       SPECTR8
               COVAR
  C
                                                                                       SPECTR81
                 MNCVIN
  C
                                                                                       SPECTR8
                 MNCV
  C
                                                                                       SPECTR9
  C
               CORREL
                                                                                       SPECTR9:
               SFA07F
                                                                                       SPECTR9
               HEMDET
  C
                                                                                       SPECTR9
  C
                                                                                       SPECTR9
  C
                                                                                       SPECTR9
         SUBROUTINE SPECTR (IMAGE, X, ILINE, IXDIN, IYDIN, NOIN)
                                                                                       SPECTR91
  C
                                                                                       SPECTR9,
        DIMENSION IMAGE(IYDIN.IXBIN.NDIN), ILINE(1), TITLE(14), AR (5),
               LABEL (8),209(8,8),300(8,8),X(14010,1X020,NDIN)
                                                                                       SPECIFISH
                                                                                       SPECTR9
         CHARACTER ROW+12,001*12,TTL*6(14)
                                                                                       SPEC TROI
         EQUIVALENCE (ROW, TTL (13)), (COL, TTL (11))
                                                                                       SPECTRO:
         LOGICAL OPT, PNCH
         NAMELIST /PARAM/ NDIM NUMLIN NUMPPL FMT TITLE OPT TOIST IRSTRT.
                                                                                       SPECTRO:
                                                                                       SPECTRO.
                            IRSTOP, LAPHOR, LAPVER, PNCH
                                                                                       SPECTRO
         DATA TTL (1) / COVARIANCE OVER SUBIMAGE --- '/. TTL (6) / CORRELATION
```

1 10

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. 1

2-12-74	18.629	CROSS-BANG TEXTURE ANALYSIS	
70	FORMATI' FRRORIDIST	HUST NOT EXCEED *, 14)	SPECTRS
32	STOP		SPECTRS
12	IF (LAPHOR .LT . NUMPPL) G	O TO 15	SPECIPS
13	WRITE(6,14)		SPECTRE
. 13	07.00		SPECTOR
. 44	CODMATE FATAL FRROR	OVERLAP EXCEEDS SIZE OF SUBINAGE*)	SPECTR6
14	IF (LAPVER GE . NUMLIN) G	0 TO 13	SPECTRE
15	IF (NUMLIN.LE.IYDIM) GO	TO 17	SPECTR6
	THE THE LET A CALL THE THE		SPECTR6
	FORMATION NUMBER OF THE	*,13, * LINESEXECUTION TERMINATED *)	SPECTRE
16			SPECTR6
_	STOP		SPECTR6
C			SPECTRE
C	HERER CECTION IT P	ROCESS THE SUBIMAGES *****	SPECTRY
C	AAAAA SEGITON II -		SPEC 127
C		INITIALIZE THE GETIM PROGRAM	SPECTR7
C	CALL CETTMET THE THE THIST.	NDIM, IRSTRT, IRSTOP, NUMLIN, NUMPPL, LAPVER,	SPECTR7
17	1 LAPHOR, NHOR, INCR, IP	ENT)	SPECTR7
	I PARMOK MADK THOK 3 TO	INITIALIZE HEMP PACKAGE PGYS	SPECTP7
C	CALL SETDIM(COV, MDIN, MD	TNI	SPECTP7
	CALL SEIDIMICOATHDINAND	SET THE OUTPUT FILE FOR TAPE OR PUNCH	SPECTR7
C			SPECT97
	KDIM=NDIM-1		SPECTR7
	IF=01		SPECTRE
	IF (PNCH) IF=43	FIND THE ROW GOORD AND THE LAST ROW	SPECT98
C	SOON TOCTOT ( AND MI THE LAG		SPEGIRA
	NROW=IRSTRT/ (NUMLIN-LAF LASTIM=(IRSTOP-IRSTRT+1	AZINIM TN-1 APVER1+1	SPECT98
	LASTIM= (IRSTUP=IRSTRICT	ANAMOUT TALENT ACTION	SPECTRA
	KPE=NUMPPL+IDIST		SPECTRE
	DO 100 M1=1.LASTIM		SPECTR8
182 8 8	NROW=NROW+1	SET UP FOR TITLE OF MATRICES	SPECTRE
C.		PUT THE COORD_NATE ANTO HOLLERITH	SPECTRE
C		LITERAL FOR MATRIX PRINTING	SPECTRE
C		ETTERNE FOR DRIVER PARTY OF	SPECTR9
	ENCODE (ROW, 8) NROW		SPECTR9
8	FORMAT(16,6X)	GET A ROW OF HORIZ OVERLAPPING	SPECTRS
C		SUBIMAGES FROM ERTS AND PUT THEM ON	SPECTR9
C		DISC FILES 11,12,13,14 FOR 4 BANDS	SPECTR9
C			SPECTRS
	CALL GETIT	PULL OFF EACH SUBIMAGE, GOING ADROSS	SPECTR9
C		THE ENTIRE ROW	SPEC TP9
C	회사를 보냈다. 이 그는 생각을		SPECTRS
	KS=-INCR	물리가 되었는데 하는데 하는데 하는데 <b>생해하다</b> 고 있다. 그리다고 하네요.	SPECTRS
	DO 90 NCO_=1.NHOR	SET START AND END PTS FOR SUBIMAGE	SPECTRE
C			SPECTRO
	KS=KS+INCP	GO THRU NUMLIN LINES	SPECTRO
C		na ta jug <b>uu toku hulleki ekse</b> n aheen oo ka billa billa billa bila dha Daga baasa asaa ka baaraa baaraa ah baasa baaraa baaraa billa billa billa billa billa billa billa billa billa b	SPECTRO
	DO SO LLN=1.NUMLIN	[발생님 : [발발] - 요. 요. 아 요. 요 하는 이 아름아버렸다.	SPECTRO
	JP=IPENO*(LLN-1)	READ A LINE OF THE SUBIMAGE	SPECTRO
C	원 : [1] [12] [13] [14] [14] [15] [16] [16] [16] [16] [17]	KCAD A LINE OF THE COSTINGS	SPECTRO
	DO 45 KOL=1.KPE	#11. 1. 19 전 1일 점점 하는 사람들이 없는 사람들이 나를 보냈다.	SPECTRO
	IP=JP+KS+KOL	READ IN THE RESOLUTION CELL	SPECTRO
C	a frating stage, we from Neferral b <b>e</b>		

```
DROSS-BAND TEXTURE ANALYSIS
2-12-74
          18,629
                                                                                      SPECTRO
                     (IMAGE (LLN , KOL , IB) , IB=1, NDIM)
       READ (11'IP)
                                                                                      SPECTF1
       CONTINUE
 45
                                                                                      SPECTR1
       CONTINUE
 50
                                                                                      SPECT91
                                      GET THE DIFFERENCE IMAGE
 C
                                                                                       SPECTR1
       CALL DIFFER(IMAGE, X, IXDIM, IYDIM, NOIM, IDIST, NUMPPL, NUMLIN)
                                                                                       SPECTP1
                                      PUT THE COORDINATE INTO HOLLERITH
 C
                                                                                       SPECIFI1
                                      LITERAL FOR MATRIX PRINTING
 C
                                                                                       SPECTP1
       ENCODE (COL'8) NCOL
                                      GET THE COVARIANCE MATRIX FOR THIS
                                                                                       SPECTRI
 C
                                                                                       SPECTR1
                                      SUPINAGE
                                                                                       SPEC TRI
 C
       CALL COVAR (ILINF, NDIM, NUMPPL, X, IXDIM, IYGIM, NUMLIN, MDIN, COV)
                                                                                       SPECTP2
                                      WRITE OUT THE COVARIANCE MATRIX
 C
                                                                                       SPECTR2
                                      WHOSE COORDINATES ARE (NCOL, NROW)
 C
       IF(OPT) CALL SFA07F(COV, NDIM, NDIM, NDIM, 2.1, 2, FMT, TITLE, TTL(1),
                                                                                       SPECTP2
                                                                                       SPECTR2
             TTL (11) , TTL (13) , LABEL , _ ABEL)
                                                                                       SPECTR2
                                      GET THE CORRELATION MATRIX
 C
                                                                                       SPECTR2
        CALL CORREL(COV, NOIM, COR)
                                                                                       SPECTP2
                                      WRITE OUT THE CORREL MATRIX
 C
        CALL SFA97F (COR, NJIM, NDIM, NDIM, 2, 1, 2, FM, TITLE, TTL(6), TT_(11),
                                                                                       SPECTP2
                                                                                       SPECTR2
            TTL (13) , LABEL , LABEL)
                                                                                       SPECTP2
                                       COPY COR TO GOV SINCE HEMDET DESTROYS
 C
                                                                                       SPECTR3
                                       ITS INPUT MATRIX
 C
                                                                                       SPECTR3
        DO 65 I5=1,NDIM
                                                                                       SPECT93
        DO 65 J5=1+NDIM
                                                                                       SPECTR3
        COV(15, J5)=COR(15, J5)
                                                                                       SPECTRE
        CONTINUE
 65
                                                                                       SPECT93
                                       GET THE DETERMINANT FOR THE
                                                                                       SPECTRE
                                       CORRELATION MATRIX
  C
                                                                                       SPECTRS
        CALL HEMDET (GOV, NOIM, DET)
                                                                                       SPECTRE
        ENTROP= (-1.) *ALOG(DET)
                                                                                       SPECTR3
                       ENTROP
        WRITE (6,91)
                                                                                       SPECTR4
                                       SAVE THE CORRELATION COEFFICIENTS AS
  C.
                                       VECTORS FOR PRINCIPLE COMPONENTS
                                                                                       SPECTR4
  C
                                                                                       SPECTR4
        KT=KT+1
        WRITE(IF, 200) NROW, NCOL, ENTROP, ((COR(J, K+1), K=J, KDIM), J=1, KDIM), KT
                                                                                       SPECTP4
                                                                                       SPECTR4
  90
        CONTINUE
                                                                                        SPECTR4
        FORMAT( ENTPOPY MEASURE IS ., F15.5)
  91
                                                                                        SPECTR4
        CONTINUE
  100
        FORMAT(213,1X,E13.6,6F10.6/8F10.6/8F10.6/6F10.6,15X,15)
                                                                                        SPECTR4
  200
                                                                                        SPECTR4
         STOP
                                                                                        SPECTR4
         END
 7 MEMORY EXPANDED. USE SLIMITS OR CORE OPTION FOR NEXT RUN
```

```
GETIMOO!
                         GET THE IMAGE FROM ERTS
CGETIM
                                                                                   GFT: MOO?
                                                                                   GETIMO0:
                                                               JAN 1974
      HRITTEN BY RJ BOSLEY
C
                                                                                    GET: MOGA
C
                                                                                    GETIMOUS
      DESCRIPTION OF PROGRAM
C
                                                                                    GETIMODE
         THIS PROGRAM IS INITIALIZED BY CALLING GETIM.
                                                           ALL FOLLOWING
      CALLS MUST BE TO GETLY WHICH GETS THE SUBIMAGE FROM THE ERTS
                                                                                    GETIMU07
                                                                                    GETIMOOF
      DATA TAPE ON FILE CODE "ES", AND OUTPUTS A ROW OF OVER_APPING
C
                                                                                    GETIMO D
      SUBINAGES TO DISC FILE 11.
C
                                                                                    GETIMO10
                                                                                    GETIM011
      INTERNAL PARAMETERS.
                                                                                    GETIMO 12
                                    LENGTH OF ONE ERTS LINE OF DATA
                LENGTH
                                    NUMBER OF LINES TO SKIP AFTER
                                                                                    GETIMB1
                NOSK
C
                                                                                    GETIMO14
                                       REWINDING ERTS INPUT TAPE
                                                                                    GFTIM015
                                     STARTING LINE IN ERTS DATA FILE
                LNSTRT
                                     VERTICAL INCREMENT FOR THE NEXT ROW
                                                                                    GETIMO16
                LNINCR
                                                                                    GETIMC17
                                     ARRAY CONTIANING CROSS BAND N-TUPLE
                                                                                    GETIMO1
                                       COMPONENTS
                                                                                    GETIMO15
                                                                                    GETIMOZE
       ENTRY POINT.
C
          CALL GETIM (ILINE, IDIST, NDIM, IRSTRT, 1RSTOP, NUMLIN, NUMPPL,
                                                                                    GETIMU21
C
                                                                                    GETIM022
                          LAPVER, LAPHOR & NHOR, INCR, IPEND)
                                                                                    GETIM023
Ċ
                                                                                    GETIMD24
       INPUT ARGUMENTS.
C
                                                                                    GETIM025
                                     ARRAY WHERE ERTS LINE IS READ INTO
                ILINE
                                     DISTANCE BETWEEN NEIGHBORING CELLS
                                                                                    GETIMO 26
                IDIST
C
                                                                                    GETIM027
                                       TO FORM DIFFERENCE ARRAY
                                     NUMBER OF COMPONENTS OF EACH RES CELL
                                                                                    GETIMO24
Č
                NDIM
                                     STARTING LINE OF ERTS BATA FILE
                                                                                    GETIMU2'
                 IRSTRT
C
                                                                                    GETIM030
                                     ENDING LINE OF ERTS DATA FILE
CC
                 IRSTOP
                                                                                    GETIMO31
                                     NUMBER OF LINES IN SUSIMAGE
                NUMLIN
                                                                                    GETIM032
                                     NUMBER OF COLUMNS IN SUBIMAGE
                 NUMPPL
                                                                                    GETIMO3
                                     NUMBER OF LINES SUBIMAGES OVERLAP
                 LAPVER
                                                                                    GETIM034
                                     NUMBER OF COLUMNS SUBIMAGES OVERLAP
                 AP HOR
 C
                                                                                    GETIMO35
 C
                                                                                    GETIM03F
       OUTPUT ARGUMENTS.
 C
                                                                                    GETIM037
                                     NUMBER OF HORIZONTAL OVERLAPPING
                 NHOR
 C
                                                                                    GETIMO3:
                                       SUBIMAGES PER ROW
 C
                                     HORIZONTAL INCREMENT FOR FIRST COL OF
                                                                                     GETIM030
 C
                 INCR
                                       THE NEXT SUBIMAGE IN THE ROW
                                                                                    GETIM041
 C
                                                                                     GETIMO41
                                     LAST POINT IN ROW
                 IPEND
                                                                                     GETIMO42
                                                                                     GETIMO43
       SUBROUTINE GETIM (ILINE, 101ST, NDIM, IRSTRT, IRSTOP, NUMLIN, NUMPPL,
                                                                                     GETIMO 46
                           LAPVER, LAPHOR, NHOR, INCR, IPEND)
                                                                                     GETIM045
 C
                                                                                     GFTIM046
       DIMENSION ILINE(1),F(8)
                                                                                     GETIMO 47
                                     INITIALIZE ERTS INPUT TAPE
 C
                                                                                     GETIMO48
       CALL EINIT (LENGTH)
                                                                                     GETIM04
       WRITE (6,4) LENGTH
                                                                                     GETIM050
       FORMAT( LENGTH OF ONE ERTS LINE IS .. 16)
                                     CHECK THE NO. OF WORDS PER RECORD
                                                                                     GETIM051
 C
                                                                                     GETIN052
        IF (LENGTH.LE.3300)
                            GO TO 5
```

GETIM053

```
WRITE(6.1) LENGTH
      FORMAT( = LENGTH OF ERTS LINE EXCEEDS 3300 -- LENGTH= +, 16)
                                                                                     GETIM054
                                                                                     GETIM055
      STOP
                                                                                     GETIM056
                                     REWIND THE INPUT TAPE
C
                                                                                     GFTIM057
      CALL EREWND
                                                                                     GETIM058
                                     FIND THE STARTING LINE OF FIRST ROW
C
                                                                                     GETIM059
                                     AND INCREMENT FOR SUCJESSIVE ROWS
                                                                                     GFTIMO60
      TRSTR=IRSTRT-L
                                                                                     GETIMO61
      LNSTRT=IRSTR
                                                                                     GETIMO62
      LNINGR=NUMLIN-LAPVER
                                                                                     GETIMO63
      ASSIGN 951 TO JP
                                                                                     GETIMO64
      ASSIGN 971 TO KP
                                                                                     GETIMO65
                                     IF THERE IS NO OVERLAP, DO NOT REWIND
C
                                                                                     GETIMB6F
                         GO TO 940
       IF (LAPVER.NE.0)
                                                                                     GETIM067
       ASSIGN 950 TO JP
                                                                                     GETIMO68
       ASSIGN 970 TO KP
                                     FIND FNDING HORIZONTAL POINT IN EACH
                                                                                     GETIMO69
C
                                                                                      GETIMO76
                                     LINE OF THE ROW, AND THE NUMBER OF
                                     OVERLAPPING SUBINAGES OF NUMPPL POINTS
C
                                                                                     GETIM071
C
                                                                                      GETIMO72
                                     THAT WILL FIT ACROSS THE ROW
                                                                                      GETIMO73
       LEN= (LENGTH-32)/4
940
                                                                                      GETIM074
       NHOR=0
                                                                                      GETIMO75
       IPEND=8
                                                                                      GETIMD76
       INCR=NUMPPL-LAPHOR
                                                                                     GETIMO 77
                                     INCREMENT THE ENDING POINT
                                                                                      GETIMO78
      - IPEND=IPEND+INCR
1991
                                                                                      GETEMO75
       NHOR=NHOR+1
                                                                                      GETIMO89
       K=IPEND+NUMPPL+IDIST
                                                                                      GETIMOS:
                                      TILL NO MORE SUBIMAGES WILL FIT
                                                                                      GETIMO88
C
       IF (K.LE.LEN) GO TO 1991
                                                                                      GETIM083
       IPEND=IPEND-INCR+NUMPPL+IDIST
                                                                                      GETIM084
                                      SKIP THE FIRST 8 POINTS IN EACH LINE
                                                                                      GETIMO85
       IS=32
                                                                                      GETIM086
                                      FIND THE LAST POINT IN EACH ERTS LINE
                                                                                      GETIMB87
       IF=IPEND+4+32-1
                                                                                      GETIMO 85
       WRITE(6,955) LEN, IPEND, NHOR
      FORMAT( TOTAL POINTS PER ROW IS .16 / FINAL POINT IS .16/
1 NUMBER OF OVERLAPPING HORIZONTAL SUBIMAGES IN THE ROW IS .15)
                                                                                      GETIMO85
 955
                                                                                      GETIM090
                                                                                      GETIMO91
                                      SET THE RANDOM DISC FILE FOR A FIXED
                                                                                      GETIM092
                                      LENGTH OF NOIM WORDS PER RECORD
 C
                                                                                      GETIMO93
       CALL RANSIZ(11, NDIM, 1)
                                                                                      GETIMO94
                                      SKIP TO THE LINE BEFORE IRSTRT
                                                                                      GETIMO99
 C
        IF (IRSTR.FQ.0). RETURN
                                                                                      GETIMO 96
        CALL ESKIP (IRSTR)
                                                                                      GETIM097
       RETURN
                                      ENTRY POINT TO GET A ROW OF SUBIMAGES
                                                                                      GETIM098
                                                                                      GETIMO9°
        FNTRY GETIT
                                                                                      GETIM100
 C
                                                                                      GETIM101
        GO TO JP, (950, 951)
                                                                                      GETIM102
                                      CHECK FOR FIRST CALL-IF SO, JOHT SKIP
                                                                                      GETIM103
                               GO TO 950
        IF (LNSTRT.EQ. IRSTR)
 951
                                                                                      GETIM104
        NOSK=LNSTRT
```

GET THE . MAGE FROM ERTS

18.736

2-12-74

221

7 MEMORY EXPANDED. USE SLIMITS OR CORE- OPTION FOR NEXT RUN

DIFFERD

```
GET THE DIFFERENCE ARRAY
CDIFFER
                                                                                   DIFFERO
                                                                                   DIFFERO
                                                               JAN 1974
      WRITTEN BY RJ BOSLEY
C
                                                                                   DIFFERD
C
                                                                                   CIFFERD
      DESCRIPTION OF PROGRAM
C
         THIS PROGRAM REPLACES THE ORIGINAL IMAGE IN WITH THE NEAREST
                                                                                   DIFFERO
C
                                                                                   DIFFERO
      NEIGHPOR HORIZONTAL DIFFERENCE, (I1-J1, I2-J2,..., IN-JN) WHERE
C
      I AND J ARE N-DIMENSIONAL HORIZONTALLY NEIGHBORING RESOLUTION
                                                                                   DIFFERO
C
                                                                                   DIFFERD
      CELLS OF DISTANCE IDIST. NOTE THAT THE ABSOLUTE VALUE IS USED
C
      GIVING ONLY THE POSITIVE HALF OF THE DISTRIBUTION OF
                                                                                    DIFFER1
C
                                                                                   DIFFER1
C
      DIFFERENCES I-J AND J-I.
                                                                                    DIFFER1
C
                                                                                    CIFFER1
      ENTRY POINT.
C
         CALL DIFFER (IA-X.IXDIM, IYDIM, NDIM, IDIST, NUMPPL, NUMLIN)
                                                                                    DIFFER1
C
                                                                                    DIFFER1
C
      ARGUMENTS.
                                                                                    DIFFER1
                                    THE SUBIMAGE BEING PROCESSED
C
                IA
                                                                                    DIFFER1
                                     DIFFERENCE ARRAY
                X
C
                                                                                    DIFFER1
                                     COL DIMENSION OF X
                IXDIM
C
                                                                                    DIFFER1
                                     ROH DIMENSION OF
                IYDIM
C
                                                                                    DIFFFRE
                                     THE DIMENSION OF EACH RESOLUTION CELL
C
                NOIM
                                                                                    DIFFER2
                                     DISTANCE BETWEEN RESOLUTION CELLS
C
                IDIST
                                                                                    DIFFE92
                                     USED FOR THE DIFFERENCE ARRAY
Ç
                                                                                    DIFFER2
                                     NUMBER OF COLUMNS IN SUBIMAGE
                NUMPPL
C
                                                                                    DIFFERZ
                                     NUMBER OF LINES IN SUBLMAGE
                NUMLIN
                                                                                    DIFFER2
Ç
                                                                                    DIFFEP2
       SUBROUTINE DIFFER(IA, X, IXDIM, IYDIM, NDIM, IDIST, NUMPPL, NUML, N)
                                                                                    DIFFER2
C
                                                                                    DIFFER2
       DIMENSION IA(IYJIM, IXDIM, 1), X(IYJIM, IXDIM, 1)
                                                                                    DIFFER2
                                     GO THRU EACH DIMENSION OR BAND
C
                                                                                    DIFFER3
       DO 5 IBANU=1,NDIM
                                                                                    DIFFER3
                                     GO THRU EACH LINE
C
                                                                                    DIFFER3
       DO 4 LINE=1.NUMLIN
                                                                                    DIFFER3
                                     GO THRU ALL BUT THE LAST COLUNN
 C
                                                                                    DIFFER3
       DO 3 KOL=1.NUMPPL
                                                                                    DIFFERS
       KKOL=KOL+IDIST
                                                                                    DIFFER3
                                     REPLACE EACH RESOLUTION CELL COMPONENT
 C
                                                                                     DIFFER3
                                     BY THE DIFFERENCE
 C
       X(LINE, KOL, IBAND) = IABS(IA(LINE, KOL, IBAND) - IA(LINE, KKOL, IBAND))
                                                                                     DIFFER3
                                                                                     DIFFER3
       CONTINUE
 3
                                                                                    DIFFER4
       CONTINUE
                                                                                     DIFFER4
 5
       CONTINUE
                                                                                     DIFFER4
       RETURN
                                                                                     DIFFER4
       END
```

CCOVAR	FIND THE COVARIANCE MATRIX FOR THE SUSTINATE C	OVÁROD1 OVÁROD2
C	JAN 1974	OVAROS
č	MOTITEN BY RJ BOSLEY	OVAR004
		OVAROUS
C	DESCRIPTION OF PROGRAM THIS PROGRAM TAKES THE DIFFERENCE SUBINAGE AND CALCULATES THE	OVAROOS.
Č	THIS PROGRAM TAKES THE UIFFERENCE SOUTHAND	COVARDO7
Č	COVARIANCE MATRIX FOR 11.	COVARODA
Č	and the control of t	COVARDOS
C C	DESCRIPTION OF PARAMETERS  PERCENTAGE OF TOTAL VECTORS X FROM	COVARO19
Č	PERCENTAGE OF TOTAL VALUE ATED	COVARUII
Č	WHICH COVARIANCE 15 ONLY	SOVARO12
Č	SCR.XLINE, SAM SCRATCH ARRAYS FROR FLAG FROM MNCVIN	COVARD13
C	IER ERROR FLAG FROM MNCV	COVAR014
C	JER 2007	COVARD15
Č.	ENTRY POINT. VILLED VIL	COVARDIS
Č	CALL GOVAR (XLINE, NOIM, NOMPPL, A, 1 ADIII, 1	COVARD17
Č	TNPHT ARGUMENTS.	COVARO18
Č	XLINE ARRAY OS USOTODS V. NO OF BANDS	CONARD19
· Č	MULIIaco ac co HMNS IN SUBJERS	COVARO20
Ç	NOTE TO A STOREGIST AND A TOREGOIST AND A TORE	COVARU21
C	A A CNCTONC OF Y	COVARD22
	IXDIM, IYDIM COL, ROW DIMENSION SHE MAG-	COVARDES
C	NIMBER OF LINES IN SOCIETY	COVARU24
Č	NOIN DIMENSION OF DOV ARRAY	COVARDES
Č	and the control of t	COVARDES
Č	OUTPUT ARGUMENTS. COVARIANCE MATRIX FOR THE SUB_MAGE	COVARD27
C	COV COVARIANCE MATRIX FOR THE SOSTINE	COVAROZE
Č		COAVESTO
Č	SUBROUTINE COVAR (XLINE, NDIM, NUMPPL, X, IXDIM, LYDIM, NUMLIN, NDIM, COV)	COVARO31
	SUBROUTINE COVAR (XLINE, NULH, NORF, LYXY INCL.)	COVARUSI
C	DIMENSION X(IYDIM, IXDIM, 1), XLINE (NDIM, NUMPPL), XMEAN(8), SIR(8),	COVARO 32
	DIMENSION X(IYDIM, IXDIM, I), XCINCIND IN, NDIN)	COVARD3?
		COVARO34
	PERCHT=100.0 INITIALIZE THE COVARIANCE PROGRAM	COVARO35
C	CALL MNCVIN(NUMPPL, NDIM, NUMLIN, PERCNT, 1, XLINE, NTRUTH, COV, XMEAN,	COVARDSE
	CALL MNCVIN(NUMPPL, NDIM, NONCIN, PERCON, VIVE	COVARO37
	1 SCR, SAM, IER, JER) CHECK FOR AN ERROR	COV AP 0 38
C		COVARO3
	IF (IER.EQ.0) GO TO 1	COVARO41
	WRITE(6,2) IER	COVAPO4:
2	FORMAT( ERROR IN MNCVIN, IERROR IS 13)	COVAR042
	STOP THE PROPERTY OF THE PROPE	COVARO4
1	CONTINUE GO THRU EACH LINE OF UBIMAGES	COVARD4
C		COVARD4
	00 10 LINE=1, NUMLIN	

### FIND THE COVARIANLE MATRIX FOR THE SUBIMAGE

02-12-74 18.927

C	GET ONE LINE OF DATA	COVARO46 COVARO47
Ÿ	DO 6 I=1.NOIM	
	DO 5 KOL=1, NUMPPL	COVAROAR
_	X_INE(I, KOL) = X(LINE, KOL, I)	COVARUA
5	CONSTRUCT	COVAROSO
6	CONTINUE INCREMENT COVARIANCE CALCULATION	S COVAROST
C		COAVAGES
	CALL MNCV CHECK FOR GROUND TRUTH ERROR	COVARDSS
C		COVAR054
	IF (JER.EQ.0) GO TO 10	COVAROSS
	WRITE (6,7) JER	COVAROSE
7	FORMAT( * ERROR IN MNCV, JERROR IS *,12)	COVARD57
	STOP	COVAROSS
10	CONTINUE	- · · · · · · · · · · · · · · · · · · ·
C	NOTE***ONLY THE POSITIVE DIFFERE	
č	WERE USED IN THE CALCULATIONS	
Č	TRUE MEAN MUST BE ZERO. SO WE M	COVAROGE
Č	AUD XMEAN**2 TO EACH ELEMENT	
0	00 20 I=1.NDIM	COVAROSZ
	00 20 J=I,NOIM	COVARD64
	COV(I,J)=COV(I,J)+XMEAN(I)+XMEAN(J)	COVAROSS
	CONCLINE ONLY IN	COVAROSE
20	COV(J,I) = COV(I,J)	COVAR067
	RETURN	COVAROSE
	END	

CHNCV

HNCVIN - MNCV

0000

IDENTIFICATION

0000

C

CCC

CCC

CC

C

C

C

C

CC

C

C

PROGRAM NAME OTHER ENTRY POINT SYSTEM

SOURCE LANGUAGE AUTHOR

DATE

HNCVÍN HNČV PÚP-15 FORTRAN ÍV

JAMES D YOUNG

8/18/73

#### PURPOSE

TO CALCULATE THE MEAN VECTOR AND COVARIANCE MATRIX FOR EACH CATEGORY OF A SET OF VECTORS. THE CALCULATIONS WILL BE BASED ON A SPECIFIED PERCENTAGE OF THE VECTORS RANDOMLY CHOSEN WITHIN THE SET.

ENTRY POINT - MNCVIN(NVPCAL, NOIM, NCALL, PERCNT, NCAT, X, NTRUTH, COV, XMEAN, SCTMEN, SAMSZ, IERROR, JERROR)

THIS INITIALIZES THE ROUTINE. AFTER MNCVIN HAS BEEN CALLED CHECK IERROR TO SEE IF IT IS NONZERO WHICH INDICATES THAT AN EOROR HAS OCCURRED.

### ENTRY POINT - MNCV

THE CALL TO MNCV SHOULD BE PERFORMED NCALL TIMES, EACH TIME WITH THE NEXT GROUP OF VECTORS IN X. IF MORE THAN ONE CATEGORY IS BEING CONSIDERED, THE GROUND TRUTH INTEGERS IN NTRUTH ASSOCIATED WITH THE VECTORS SHOULD ALSO BE UPDATED EACH TIME MNCV IS CALLED, AND JERROR SHOULD BE CHECKED AFTER EACH CALL TO SEE IF IT IS NONZERO WHICH INDICATES THAT AN ILLEGAL GROUND TRUTH INTEGER HAS BEEN FOUND. IF ONLY ONE CATEGORY IS BEING CONSIDERED HOWEVER, THE VALUES IN NTRUTH ARE NOT USED IN THE POUTINE.

AFTER MNCV HAS BEEN CALLED NCALL TIMES THE MEAN VECTOR AND COVARIANCE MATRIX FOR EACH CATEGORY IS COMPLETED. IN ADDITION, THE NUMBER OF VECTORS USED FOR THE CALGULATIONS FOR EACH CATEGORY IS OUTPUT. THESE NUMBERS SHOULD BE CHECKED WHEN APPROPRIATE TO SEE IF ENOUGH VECTORS WERE USED FROM EACH CATEGORY TO GIVE A RESONABLE ESTIMATE OF THE DESIRED STATISTICS.

#### ARGUMENTS

INPUT -

NVPCAL NUMBER OF VECTORS PER CALL

'N N C V I N - M N C V

72-79-74 20 .440

00000

C

C

C

C

C

C

C

CCC

C

C

C

C

CCC

C

C

C

C

Ç

C

C

CC

C

NOIM

DIMENSION OF DATA VECTORS

NCALL NUMBER OF CALLS

PERCENTAGE OF TOTAL NUMBER OF VECTORS FROM HHIGH MEAN AND COVARIANCE MATRICES WILL BE CALCULATED

NCAT NUMBER OF CATEGORIES CONSIDERED =1 IF ONLY ONE SET OF STATISTICS WILL BE CALCULATED FOR ALL DATA

CALCULATED FOR ALL DATA

=NUMBER OF CATEGORIES IN DATA IF ONE SET OF
STATISTICS WILL BE CALCULATED FOR EACH CATEGORY

X (NDIM, NVPCAL) MATRIX CONTAINING INPUT DATA VECTORS IN ITS COLUMNS

NTRUTH NTPUTH(NVPCAL) VECTOR CONTAINING THE GROUND TRUTH INTEGERS, 1 THROUGH NCAT, ASSOCIATED WITH THE DATA VECTORS OF X. IF NCAT EQUALS 1 THIS VECTOR WILL NOT BE USED.

OUTPUT -

COV (NDIM, NDIM, NCAT) MATRIX CONTAINING COVARIANCE MATRIX/MATRICES OF THE DATA

XMEAN XMEAN(NOIM, NCAT) MATRIX CONTAINING MEAN VECTOR/VECTORS OF THE DATA

SCIMEN SCIMEN(NDIM, NCAT) SCRATCH MATRIX CONTAINING AN ESTIMATE OF THE MEAN VECTOR/VECTORS

SAMSZ SAMSZ (NGAT) VECTOR CONTAINING NUMBER OF VECTORS USED TO CALCULATE THE STATISTICS FOR EACH CATEGORY

IERROR ERROR INDICATED IF RETURNED NONZERO

=1 IF NVPCAL .LE. 0 =2 IF NDIM .LE. 0

=3 IF NCAL .LE. 0

=4 IF PERCNT .GT. 100. OR PERCNT IS SO SMALL THAT FEWER THAN 2 VECTORS WILL BE USED TO CALCULATE ALL THE STATISTICS

=5 IF NCAT .LE. 0
(IF MORE THAN ONE OF THESE ERRORS OCCURS,
THE HIGHER VALUE WILL BE RETURNED)

JERROR ERROR INCICATED IF RETURNED NONZERO
=1 IF ILLEGAL GROUND TRUTH LABEL IS FOUND

INTERNAL PARAMETERS

```
MNCVIN - MNCV
           20.440
12-03-74
                      NUMBER OF TIMES MNCV HAS BEEN CALLED
  C .
              ICALL
                      TOTAL NUMBER OF VECTORS WHICH WILL BE INPUT TO MNCV
             VECTS
  C
                      TOTAL NUMBER OF VECTORS TO BE USED IN CALCULATION
              VTBU
  C
                      OF STATISTICS
  C
                      NUMBER OF VECTORS LEFT TO BE USED IN CALCULATION
  C
              VLTBU
                      OF STATISTICS
                      NUMBER OF VECTORS LEFT TO BE CONSIDERED
  C
              VLEF T
                       INTEGER DENOTING GROUND TRUTH CATEGORY
              INTRU
  C
                      ARGUMENT TO ROM
ARGUMENT TO ROM
  C
              IP.
              IO
  C
  C
  C-
  C
                                    INITIALIZER ENTRY POINT
  C
  Ç
        SUBROUTINE MNCVIN(NVPCAL, NDIM, NCALL, PERCNT, NCAT, X, NTRUTH, COV,
                            XMEAN, SCIMEN, SAMSZ, IERROR, JERROR)
        1
  C
  C
         DIMENSION X (NOIM, 1), NTRUTH (1), COV (NDIM, NDIM, NCAT), XMEAN (NCAT, 1),
        1 SOTHEN (NOTH,1), SAMSZ (NCAT)
         ICALL=0
         VECTS=NVPCAL+NCALL
         TERROR=#
         NVTBU=VECTS*PERCNT/100.+0.49999
         VIBU=NVIBU
         VLTBU=VTBU
         VLEFT=VECTS
         INTRU=1
         IP=33333
         IQ=55555
         JERROR=0
  C
                                     CHECK LEGALITY OF SOME NUMBERS
   C
         IF (NVPCAL . LE . 0) IERROR=1
         IF(NDIM .LE.O) IERROP=2
IF(NCALL .LE.O) IERROR=3
         IF (PERCYT.GT.100..OR.VT3U.LT.2.) IERROR=4
         IF (NCAT .LE.0) IERROR=5
   C
                                   ZERO OUT A FEW ARRAYS
   C
   C
         DO 14 K=1 , NCAT
          SAMSZ(K)=0
          DO 14 J=1.NDIM
          XMEAN (J.K)=0
          SCIMEN (J.K) =0
                               REPRODUCIBILITY OF THE
          DO 14 I=1.NDIM
                               ORIGINAL PAGE IS POOR
      14 COV(I.J.K)=0
   C
```

```
MNCVIN - MNCV
           20.440
02-09-74
                                 SET TPANSFER TO REFLECT NUMBER
  Ċ
                                 OF CATEGORIES
  C
  C
        ASSIGN 5 TO IGO
        IF (NCAT.GT.1) ASSIGN 15 TO IGO
        RETURN
  C
                                  ENTRY POINT FOR ALL CALLS AFTER THE FIRST
  C
  C
  C
        ENTRY MNCY
  Ç
        ICALL=ICALL+1
        IF((ICALL/50)*50.NE.ICALL.AND.ICALL.NE.10) GO TO 1
                                  UPDATE ESTIMATE OF THE MEANS AND MODIFY
                                  COVARIANCE CALCULATIONS TO REFLECT
  CCC
                                  THIS UPDATE
         DO 10 K=1.NCAT
         IF (SAMSZ(K) . E0.0.) GO TO 10
         00 2 J=1,NDIM
       2 COV(I,J,K)=COV(I,J,K)-SAMSZ(K)*(XMEAN(I,K)/SAMSZ(K)-SCTMEN(I,K))*
        1 (XMEAN (J.K)/SAMSZ (K)-SCTMEN (J,K))
         DO 3 J=1, NOIM
         SCTMEN(J,K) = XMEAN(J,K)/SAMSZ(K)
       3 CONTINUE
      18 CONTINUE
                                   CONTINUE TO CALCULATE MEAN AND
   C
                                   UPPER TRIANGLE OF COVARIANCE MATRICES
   C
   Č
       1 00 8 I=1, NVPCAL
                                   DETERMINE WHETHER TO SKIP THIS VECTOR
   C
         IF (RCM(IP+IQ).GT.VLTBU/VLEFT) GO TO 11
                                   INCLUCE THIS VECTOR IN CALCULATIONS
          VLTBU=VLTBU-1.
          GO TO IGO, (15,5)
                                    WE ARE TO CONSIDER MORE THAN ONE
    CC
                                    CATEGORY
       15 INTRU=HTRUTH(I)
                                    CHECK LEGALITY OF GROUND TRUTH LABEL
```

```
·HNCVIN - HNCV
           20.440
02-09-74
        IF (INTRU.LE.O. OR. INTRU. GT. NCAT) GO TO 9
      5 00 4 J=1.NOIM
                                   SUM FOR MEAN
  C
  C
        XMEAN(J.INTRU) = YMEAN(J, INTRU) + X(J, I)
        00 4 K=1,J
                                   SUM FOR FOR COVARIANCE
  C
        COV(K,J,INTRU)=COV(K,J,INTRU)+(X(J,I)-SCTMEN(J,INTRU))*(X(K,I)-
       1 SCIMEN(K, INTRU))
      4 CONTINUE
        SAMSZ(INTRU) = SAMSZ(INTRÚ) +1.
     11 CONTINUE
        VLEFT=VLEFT-1.
      8 CONTINUE
        IF (ICALL.LT.NCALL) RETURN
  CCCC
                                   ALL VECTORS HAVE BEEN INPUT
                                   FINISH CALCULATION OF STATISTICS
         DO 7 K=1 . NCAT
        IF (SAMSZ(K).EQ.O.) GO TO 7
        DO 6 J=1.NDIM
        DO 6 I=1.J
        COV(I,J,K)=COV(I,J,K)/SAMSZ(K)-(XMEAN(I,K)/SAMSZ(K)-SCTMEN(I,K))+
          (XMEAN (J.K) / SAMSZ (K) - SCTMEN (J.K))
  CCC
                                   FILL IN LOWER TRIANGLE
       6 COV(J,I,K)=COV(I,J,K)
         DO 13 J=1,NOIM
         XHEAN (J.K) = XMEAN (J.K) /SAMSZ (K)
      13 CONTINUE .
      7 CONTINUE
      12 CONTINUE
         RETURN
       9 JERROR=1
         GO TO 12
         END
```

F

```
GET THE CORRELATION MATRIX FOR THE SUBINAGE
           18.936
02-12-74
                                                                                       CORREL 01
                      GET THE CORRELATION MATRIX FOR THE SUBIMAGE
                                                                                       CORREL 02
  CCORPEL
                                                                                        CORREL 03
                                                                  JAN 1974
        HRITTEN BY RJ BOSLEY
                                                                                        CORREL 04
  C
                                                                                        CORREL 05
  C
        DESCRIPTION OF PROGRAM
                                                                                        CORREL 05
           THIS PROGPAM CALCULATES THE CORRELATION MATRIX GIVEN THE
  C
                                                                                        CORREGO7
  C
         COVARIANCE MATRIX AND ITS ORDER.
                                                                                        CORREL 08
  C
                                                                                        CORPELOS
  C
                                                                                        CORREL10
         ENTRY POINT.
  C
                 WALL SORREL (COV.NO.M.COR)
                                                                                        CORPEL 11
  Č
                                                                                        CORREL12
  C
         ARGUMENTS.
                                       COVARIANCE MATRIX ARRAY
                                                                                        CORPE_13
                   COV
  C
                                        ORDER OF MATRICES
                                                                                        CORRE-14
                   NOIM
  č
                                        CORRELATION MATRIX ARRAY
                                                                                        CORREL 15
                   COR
  C
                                                                                        CORRELIE
  C
         SUBROUTINE CORREL (COV, NDIM, COR)
                                                                                        CORREL 17
                                                                                        CORREL15
 · C
         DIMENSION COV(NDIM, NDIM), COR(NDIM, NDIM)
                                                                                        CORREL1°
                                        GO THRU EACH ROW OR LINE
                                                                                        CORRELEI
                                                                                        CORREL 21
         DO 10 LINE=1.NOTH
         COVLEABS (COV (LINE, LINE))
                                                                                         CORREL 21
                                        GO THRU UPPER DEAGONAL
                                                                                         CORRELZL
   C
         DO 9 KOL=LINE, NOIM
                                                                                         CORRE_ 21
         COVC=ARS(COV(KOL,KOL))
                                                                                         CORREL 25
         COR(LINE, KOL) = COV(LINE, KOL) / SQRT (COVC*COVL)
                                                                                         CORRELES
          COR(KOL.LINE) = COR(LINE, KOL)
                                                                                         CORREL 27
   9
                                                                                         CORRELE
         CONTINUE
   10
                                                                                         CORREL 2'
          RETURN
```

END

IV.2-d Piecewise Linear Classification Program Listings

RCLASS
XIN
LINEAR
WEIGHT

```
RULASS01
                   PATTERN VECTOR CLASSIFICATION
                                                                            RULASS02
CRCLASS
                                                                            RCLASS03
                                                              SEPT 1972
      WRITTEN DY SAM SHANMUGAM
                                                                            RCLASS04
                                                                  1973
                                                              DEC
      DOCUMENTED BY RJ BOSLEY
                                                                            RCLASS05
                                                                            RCLASSOR
                                                                            RCLASS07
C
         THIS SUBROUTINE CLASSIFIES A GIVEN SET OF PATTERN VECTORS INTO RCLASS OR
      DESCRIPTION OF PROSPAM.
C
      OHE OF MANY POSSIBLE CATEGORIES USING THE INFORMATION CONTAINED
                                                                            ROLASSIP
      IN A SET OF TRAINING PATTERNS WHOSE CATEGORIES ARE KNOWN.
                                                                            RCLASS11
                                                                            RULASS12
                                                                            RCL ASS13
      ENTRY POINT.
                               CA_L ROLASS (WORK, ISIZE)
                                                                            ROLASS 14
                                                                             RCLASS15
C
                                                                             RCLASS16
      INPUT ARGUMENTS.
                    WORK - SCRATCH ARRAY USED BY ROLASS
                                                                             RCLASS17
                    ISIZE - SIZE OF THE SCRATCH ARRAY WORK . THE ARRAY
                             WORK MUST BE DIMENSIONED IN THE CALLING
                                                                             RCLASS18
                             PROGRAM, WITH A DIMENSION GREATER THAN OR
                                                                             RCLASS19
 CCC
                             EQUAL TO ISIZE. THE VALUE OF ISIZE IS GIVEN
                                                                             RCLASS20
                                                                             RCLASS21
                                                                             RCLASS 22
                                     ISIZE=NDIM*(NTRAIN+10)+1000
 C
                                             + (NC* (NC+1)/2) *ND+YPAIR*NO
                                                                             RCLASS23
 Ċ
                                                                             RGLASS24
                             WHERE ND=NDIM-1
                                                                             RCLASS 25
 C
                                                                             RCLASS26
                                                                             ROLASS27
       INPUT PARAMETER CARDS.
          CARD 1. SHOULD CONTAIN THE PROGRAM OPTION PARAMETERS NOPT1,
                                                                             ROLASSEE
                                                                             RCL ASS 25
 C
                   NOPT2, NOPT3, NOPT4, IN FORMAT (411) ..
                                                                             ROLASS30
                     IF (NOPT1.NE.0) THE TRAINING PATTERNS ARE PRINTED OUT ROLASS31
 C
                     IF (NOPTZ . NE . B) THE TEST PATTERNS ARE PRINTED OUT
                                                                             RCLASS37
                     IF (NOPT3.NE.U) THE CLASSIFICATION OF EACH TRAINING
 C
                                     PATTERN IS LISTED. OTHERWISE, ONLY THE ROLASS34
 C
                                     CONTINGENCY TABLE IS PRINTED OUT
                                                                              RCLASS35
 C
                     IF (NOPT4.NE.0) THE CLASSIFICATION OF EACH TEST
                                                                              RCLASS3E
 Ç
                                                                              RCL ASS 37
                                                          OTHERHISE ONLY
                                     PATTERN IS LISTED.
 000
                                     THE CONTINGENCY TABLE IS PRINTED OUT. RCLASS38
                                                                              RCLASS35
           CARD 2. SHOULD CONTAIN PARAMETERS NTOT, NPART, NDIM, NO, NPAIR IN
                                                                              ROLASS4!
  C
                                                                              RCL ASS4
  C
                            -- TOTAL NUMBER OF PATTERN VECTORS IN THE DATA RULASS4:
                    FORMAT (515) .
                      NTOT
  C
                      NPART -- NPART OUT OF EVERY 10 PATTERN VECTORS IN THERCLASSA
  C
                               DATA SET WILL BE USED FOR TRAINING. THE
                                                                              RCL ASS45
  CCCCC
                               REMAINING PATTERNS WILL BE USED FOR TESTING RULASS4
                                THE CLASSIFIER
                            -- NUMBER OF MEASUREMENTS PER VECTOR PLUS 2
                                                                              RCLASS4
                                                                              RCL ASS4
                      NDIM
                             -- NUMBER OF GROUND TRUTH CATEGORIFS
                      NPAIR -- 2* (MAXIMUM NUMBER OF TRAINING PATTERNS IN
                                                                              RCLASS5
  C
```

```
ROLASS51
                             ANY ONE CATEGORY)
                                                                            RCLASS52
C
                                                                            RCLASS53
      INPUT DATA SET.
                                                                            RCL ASS54
C
         INPUT CATA VECTORS ARE READ IN BINARY FROM FILE CODE 01
C
                                                                            RCLASS55
      ACCORDING TO THE FOLLOWING READ ---
C
                    READ(01) IGT.M1,N1,NFT,(FEAT(I),I=1,NMEAS)
                                                                            RCLASS56
                                                                            RCLASS57
                         IS THE GROUND TRUTH CATEGORY
      WHERE
                                                                            RCLASS 58
               MI.NI.NET ARE NOT USED (MAY BE USED AS TO TAGS)
                                                                            RCLASS 59
C
                         IS THE FEATURE VECTOR I-TH COMPONENT
               FEAT(I)
                         IS THE NUMBER OF JOMPONENTS OR MEASUREMENTS IN
C
                                                                            RULASSAD
               NMEAS
                                                                            RCLASS61
                         EACH FEATURE VECTOR=NDIM-2.
C
      THE DATA FILE SHOULD HAVE A TOTAL OF NTOT LOGICAL RECORDS IN
                                                                            RCLASS52
                                                                            RC LASS 63
C
                    EACH LOGICAL RECORD MUST BE OF LENGTH (NDIM+2)
              WORD 1 IS THE GROUND TRUTH CATEGORY AND 5 THRU NOTH+2 ARE RCLASS64
      BINARY FORM.
C
      WORDS.
                                THE PATTERN VESTORS MUST BE SORTED BY
                                                                            RCLASS65
      THE MEASUREMENT VALUES.
                  THE DATA SET IS SORTED INTO TRAINING AND TEST SETS
C
                                                                            RCLASS 56
      ACCORDING TO THE USER SPECIFIED RATIO IN NPART. TRAINING PATTERNS ROLASS67
C
      ARE COPIED TO CORE AND TEST PATTERNS ARE COPIED TO DISC ON FILE
                                                                             RCLASS68
                                                                             RCLASS59
C
      CODE 02.
                                                                            RCLASS70
                                                                             RCLASS71
C
       LIMITATIONS.
C
                                                                             RCLASS72
               1. MAXIMUM NUMBER OF CATEGORIES IS 15.
                                                                             RCLASS73
               2. MAXIMUM VALUE OF NOIM IS 100.
               3. SCRATCH DISC FILE MUST BE ON 02 AND INPUT DATA ON 01.
                                                                             RCLASS74
               4. PATTERN VECTORS MUST BE SORTED BY CATEGORY.
                                                                             RCLASS7F
                                                                             RCLASS7E
 C
                                                                             RCLASS 77
       THEORY.
 C
                     USING A PEGRESSION TYPE ALGORITHM, THE PROGRAM
                                                                             RCLASS 78
 C
                                                                             RCL ASS75
                     OBTAINS A SET OF HYPERPLANES FOR SEPARATING THE
 C
                     TRAINING PATTERNS . THE SEPARATION IS DONE FOR
                                                                             RCLASS 8 C
                     DIFFERENT CATEGORY PAIRS. A TOTAL OF NC*(NC-1)/2
 C
                                                                             RCLASS81
 C
                     HYPER PLANES ARE DETERMINED. TEST PATTERNS ARE
                                                                             RCLASS82
 C
                     CLASSIFIED ON THE BASIS OF A MAJORITY VOTE ON THESE
                                                                             RCL ASS87
 C
                                                                             RCLASS 84
                     HYPERPLANES.
 C
                                                                             RCLASS 35
                                                                             RCLASSSE
          FOP A COMPLETE DISCUSSION OF DETAILS, SEE "INTRODUCTION TO
                                                                             RCLASS87
       B_BLICGRAPHY.
       STATISTICAL PATTERN RECOGNITION . BY FUKUNAGA, ACADEMIC PRESS.
                                                                             RCLASS 85
 C
                                                                             RCLASSES
       NEW YORK, 1972.
                                                                             RCLASS9!
                                                                             ROLASS 91
       SUBPROGRAMS REQUIRED.
                                                                              RCLASS91
           DRIVER
 C
                                                                              RCLASS 9
              RCLASS
 C
                                                                              RCLASS91
                 XIN
                                                                             RCLASS9F
 C
                 LINEAR
 C
                                                                              RCLASS9
                    WEIGHT
                              -- A FORTRAN CALLABLE ROUTINE FROM ISM SSP
 C
                                                                              RCLASS9
                        HINV
 C
                                                                              RCL ASS 9
                                                                              RCLASS9
 C
        EXAMPLE.
           IN ORDER TO PROCESS A DATA SET REQUIRING A SCRATCH ARRAY OF
                                                                              RCLASSO:
```

# PATTERN VECTOR CLASSIFICATION

C SIZE 1500C, THE DRIVER SET UP IS AS FOLLOWS  C C CORIVE SAMPLE DRIVER FOR CLASSIFICATION PGM  C DIMENSION WORK (15000)  C C CALL RCLASS (WORK, ISIZE)  C STOP  END  C RCLASS 09  RCLASS 09  RCLASS 09  RCLASS 10  RCLASS 10  RCLASS 10	
C CORIVE SAMPLE DRIVER FOR CLASSIFICATION PGM RCLASS03 C DIMENSION WORK (15000) RCLASS05 C ISIZE = 15000 RCLASS06 C CALL RCLASS (WORK + ISIZE) RCLASS07 C STOP RCLASS09 C END RCLASS10 RCLASS10 RCLASS10 RCLASS11	
C CORIVE SAMPLE DRIVER FOR CLASSIFICATION  DIMENSION WORK (15000)  C SIZE = 15000  CALL RCLASS (WORK • ISIZE)  C STOP  END  C END  RCLASS 09  RCLASS 09  RCLASS 10  RCLASS 10  RCLASS 11	
DIMENSION WORK(15000)   RCLASS05     C	
ISIZE = 15000   R3LASS06   CALL RCLASS(WORK+ISIZE)   RCLASS07   RCLASS07   RCLASS08   RCLASS08   RCLASS08   RCLASS09   RCLASS10   RCLASS10   RCLASS11	
C CALL RCLASS (WORK+ISIZE) C C STOP C END C END C RCLASS 09 RCLASS 10 RCLASS 10 RCLASS 11	
C CALL RCLASS (WORK 13122)  C STOP  C END  C RCLASS 0 9  RCLASS 1 0  RCLASS 1 0  RCLASS 1 1	
C	
C RCLASSIU RCLASSII	
C RCLASSIU RCLASSII	
RCL ASS 11	
U	
SUBROUTINE RCLASS (WORK, ISIZE) RCLASS12	
recommendation of the commendation of the comm	
R3LASS14	ŧ
DIMENSION WORK (ISTZE) ,DD (50)	
COMMON NTRAIN.NTEST, NDIM, ND, ND, NPAIR, ND 121101 121101 RCLASS 16	
RCLASS17	
C READ IN PARAMETER CARDS AND DATA SET RCLASSING	8
CALL XIN(WORK(1), UD(1)) RCLASS20	0
C THE RECENT AND ADDRESS OF THE RELASSED	1
C . LOCATE THE BESTING NO ABBREAR SJEPGM RCLASS 22	2
VARIOUS ARRAYS FOR THE EINEAN BELL ASS23	3
I1=1	
I2=I1+NTRAIN*NDIM	5
I3=12+NOIH RCLASS26	6
I4=I3+NH*ND . RCLASS27	27
	8
CHECK THAT IN UTILITIES ON S STACCOO	29
ARRAY IS ADEQUATE RCLASS 3	
TE(TELLELISIZE) GO TO 53	31
WRITE(6,82) 82 FORMAT(1H1,5X, PROBLEM WILL NOT FIT THE CORE ALLOTED FOR THIS PROGRCLASS 3	32
82 FORMAT(1H1,5X, PROBLEM WILL NOT FIT THE CORE ALLOTED FOR THIS RCLASS 3	33
RCLASS 3	34
RETURN RCLASS3	
UND EN DO THE CENSSITE OF THE	37
C CALL LINEAR(WORK(I1), WORK(I2), WORK(I3), WORK(I4), WORK(I5))  RCLASS3 RCLASS3	38
RETURN RCLASS3	

		· · · · · · · · · · · · · · · ·	(IN.00001
CXIN	READ IN TH	E DATA ,	CINODOOS
C		SEPT 1972	(IN00003
C	WRITTEN BY SAM SHANMUGA	M 050 1973	(IN00004
C	DOCUMENTED BY RJ BOSLEY		(IN00005
Č			KIN00006
č	DESCRIPTION OF PROGRAM.		XINDOOD7
· Č	THIS SUPROUTINE READ	S IN THE TWO PARAMETER CARDS AND THEN COPYING THE TEST PATTERNS TO DISC FILE 02.	KINOODOB
Č	READS IN THE DATA SET.	COPYING THE LEST PATTERNS TO BISS TIES	POOCONIX
Č			XINDODIO
Č	ENTRY POINT.		XIN00011
Č	CALL XIN (WORK + L		XIN00012
Č			XINOOD13
Č	INPUT ARGUMENTS.		XIN00014
Ğ	MORK	ARRAY DATA 15 ALAD 1410	XINOUD15
C	U		XIN00016
Č	in Albert Carliffe Bay and the Control of the Section 1999 of the		XIN00017
Č	INTERNAL PARAMETERS.		XIN00018
Č	NTRAIN	NII DE LEATHING LATIEN,	XIN00019
CCC	NTEST		XIN00020
Č	NDIM	STUO OF WEND PER LENGUE ATTO	XIN00021
C	ND	NDIM-1 NO. OF GROUND TRUTH CATEGORIES	XIN00022
Č	NC	TWICE MAX NO. OF TRAINING PATTERNS	XIN00023
Č.	NPAIR	TWICE MAX NO. OF TRAINING TATILLAND	XIN00024
Č	ИН	NO. OF HYPERPLANES PROGRAM OPTIONS, SEE ROLASS	XINDDD25
C	NOPT1-4	NO. OF VECTORS OUT OF 10 TO SKIP	XIN00026 -
C	NSKIP		XIN00027
		TRAINING NO. OF BLOCKS OF 10 PATTERN VECTORS	XINOUG28
C	NTIMES	THE THOUGH BOTH FILE	XIN00029
C		NO. OF VECTORS LEFT AFTER READING ALL	XINDDD3D
C	ILEFT	BLOCKS OF 10 VECTORS	XIN00031
C		BLOCKS OF TO ACOLOGO	XIN00032
C			XINODO33
C			XIN00034
	SUBROUTINE XIN (WORK, U)		XIN00035
C			XIN00036
	DIMENSION WORK (1) . U(1	DIM, ND, NC, NPAIR, NH, NOPT1, NOPT2, NOPT3, NOPT4,	XIN00037
	COMMON NTRAIN, NTEST, NO	JIM, NU, NO, NEATK, MILLIAND, 114100, 12410	XIN00038
artinagar Lista da karanta	1 NTOT, NPART	READ IN PARAMETER CARD 1.	XIN 000 39
C			XIN00040
	READ(5,100) NOPT1, NOP	READ IN PARAMETER CARD 2.	XIN00041
C			XIN00042
	READ(5,101) NTOT, NPAR	1 9 MOTIL BUT BUT WAY	XIN00043
100	FORMAT(411)	orași în ligitarii de la companie d	XIN00044
101	FORMAT (515)	READ THRU THE INPUT FILE THO TIMES	XIN00045
C		ONCE TO GET THE TRAINING PATTERNS AND	1 Y T M 0 0 0 4 15
C	얼마 뭐하는 물병에는 얼마를 보았다.	ONCE TO GET THE TEST PATTERNS	V Til OOO A
C	하는 하는 사람이 되는 것이 되었다.		XIN00048
	REWIND 01	INITIALIZE INTERNAL PARAMETERS	XIN00049
C	용이 다시일 2015 회사 회사 회사 하는 발견 원	사용 보는 보다 보고 보다 보다 보다 보다 보다 보다 되었다. 그 사람들은 사람들은 사람들은 사람들은 사람들은 사람들은 사람들은 사람들은	XIN0005D
	IREGIN=1	스트 등 등 등 하고 하고 하는데 그 나를 하는데 하는데 하는데 하는데 없다.	

	NTRAIN=0		(IN00051
	NOD=NPIM+S		(IN00052
			(INDOD53
		HILL THE EMPTH OF THE MATERIAL SECTION	XINOO054
C	in the second of	TEN TUPLIT PATTERNS PICK THE FIRST	XIN00055
C		NDAGI PATTERNO NO INNTITUTO INTERNO	XINDOSS.
C	NSKIP=10-NPART		XINDOUS?
•	MOKTA-IO-MUMA	•	XIN00053
C		WRITE HEATITMO	XIN00059
C	IF (NOPT1 . NE. 0) WRITE (6 . 201)		XINOOORD
204	- FORMATZELA, ANY, "TRAINING PAI	TERNS 1	XIN00061
201	FORMAT (THEY PART THE TERMS OF	EN THRU FACE SECON OF THE	XIN00062
C		DATTERN VECTORS	XIN00063
C	DO 20 NN=1.NTIMES		XIN00054
	TO LICKTO CO OL CO TO 16		XIN00065
	Th Marting 1 20 10 10	SKIP OVER THE TEST VECTORS	XIN00066
C	DO 15 JJ=1,NSKIP	the second secon	XIN00067
	DO 19 00-14(43/1)	READ PAST THIS VECTOR	XIN 000 68
C	READ(1) (U(K),K=1,N00)		XINOOO69
15	READULY TOTAL THE		XIN00070
C	CONTINUF		XIN00071
16	CUNTINOF	READ NEART TRAINING PATTERN VECTORS	XIN00072
C	DO 10 JJ=1, NPART		XIN00073
	00 10 22-14W 4W	COUNT THE NO. OF TRAINING VECTORS	XIN00074
C	NTRAIN=NTRAIN+1		XINDOO75
С	Marka Pin-marka Para	INDEX THIS VECTOR INTO WORK	XIN00076
·	IBEGIN=(NTPAIN-1) +NDIM+1		XIN00077
	IEND=NTRAIN*NDIM		XIN00078
	IB1=IBEGIN+1		XIN00079
	IB2=IE1+1		XIN00080 XIN00081
С	106-151-1	SET THE FIRST COMPONENT TO 1.0	XIN00031 XIN00032
·	WORK(IB1)=1.0		XIN00032
C		READ THE TRAINING PATTERN VECTORS	XIN00384
·	READ(1) WOPK(IBEGIN), NM1, NM	2, NM3, (WORK(K), K= IB2, IEND)	XINDOD35
C	KEND 121 WE WILL THE TOTAL	WRITE OUT THE TRAINING PATTERNS	
·	TE (NOPT1.NE.D) WRITE (6, 102)	NTRAIN, WORK (IBEGIN) . NM1 . NM2 . (WORK(K) .	XINGUUSC VINDUUSC
	1K=IB1.IEND)		XINOOOSS
102	FORMAT(1X,13,3X,6(F10.4))		XINOOO89
10	CONTINUE	at when the state of the second of the secon	XINDDOGG
20	CONTINUE		XIN00091
ເີ້		READ IN THE LEFTOVER PATTERNS	ZEODONIX
v	ILEFT=NTOT-10*NTIMES		XINOOD93
	IF(ILEFT.EQ.D) GO TO 26		XIN00094
	90 25 JJ=1,ILFFT		XIN00095
C		INCREMENT TRAINING VECTOR COUNT	XINODO96
7 M	NTRAIN=NTRAIN+1	그리는 사람으로 한다 <u>면 있는데 그림 보면 프로</u> 프로 나를 하다 하였다.	XINDUU 90 XINDUU 97
С		INDEX THE VECTOR INTO WORK	XINOOO98
	ISEGIN= (NTRAIN-1) #NDIM+1	얼마를 맞게요. 그 나는 이렇는 그를 시간에 이렇지만	XINOOO99
	IEND=NTRAIN*NDIM	이 보이 하는 경우 보다 경우 등에 얼마를 받는 것이 되었다.	XIN00100
	IB1=IREGIN+1	왕이 동리에 바이트로 살수 말로 이렇는 아이지 않는다. 심리하다.	

```
XIN00101
      192=191+1
                                                                             XIMODIOS
      WORK (IB1) =1.0
                                                                             XIN00103
                                    READ A TRAINING PATTERN
                                                                             XIN00104
      READ(1) WORK (IBEGIN) . NM1 . NM2 . NM3 . (WORK (K) . K=182 . IEND)
C
                                                                             XINDD105
                                    WRITE OUT TRAINING PATTERNS
      IF (NOPT1.NF.0) WRITE(6,102) NTRAIN, WORK (IBEGIN), NM1, NM2, (NORK(K), XIN00106
C
     1K=181, [END)
                                                                              XIN00108
                                                                              XINCOLD9
      CONTINUE
                                                                              XIN00110
 25
      CONTINUE
                                                                              XIN00111
      REWIND 01
                                                                              XIN00112
      REWIND 02
                                                                              XIN00113
                                     COPY TEST PATTERNS TO DISC FILE 02
                                                                              XIN00114
C
                                                                              XIN00115
C
                                     WRITE HEADING
C
                                                                              XIN 00115
       IF (NOPT2.NE.0) WPITE(6,103)
                                                                              XIN00117
 103 FORMAT (1H1, 10X, 'TEST PATTERNS')
                                                                              XIN00118
       NTEST=0
                                     SKIP IF THERE ARE NO TEST PATTERNS
                                                                              XIN00119
                                                                              XIN00120
C
       IF (NPART.EQ.0) GO TO 99
                                                                              XIN00121
       DO 45 NN=1, NTIMES
                                                                              XIND0122
       DO 43 JJ=1,NSKIP
                                                                              XIN00123
                                     COUNT THE NO. OF TEST VECTORS
                                                                              XIN00124
                                     READ INPUT DATA FILE THE SECOND TIME
       NTEST=NTEST+1
                                                                              XIN00125
                                                                               XIN00126
       READ(1) (U(KK),KK=1,NCD)
                                                                               XIN00127
                                     SET COMPONENT FOUR TO 1.0
                                                                               XIN00128
 C
                                                                               XIN00129
       U(4) = 1.0
                                     WRITE OUT THE TEST PATTERNS
                                     NTEST, U(1), U(2), U(3), (U(KK), KK=4, NOD) XIN00130
       IF (NOPT2.NE.0) WRITE(6,102)
                                     WRITE TEST PATTERN TO DISC FILE 02
                                                                               XIN00131
                                                                               XIN00132
 C
       WRITE(2) (U(KK) . KK=1,NDD)
                                                                               XIN00133
  43
                                      SKIP OVER THE TRAINING VECTORS
                                                                               XIN00134
 C
       DO 44 JJ=1.NPART
                                                                               XIN 00 135
       READ(1) (U(KK), KK=1, NDD)
                                                                             XIN00136
  44
                                                                               XIN00137
       CONTINUE
  45
       END FILE 02
                                                                               XIN00138
        REWIND 02
                                                                               XIN00139
       CONTINUE
                                                                               XIN00140
   99
        REWIND 01
                                                                               XIN00141
                                      WRITE OUT A PROGRESS NOTE
                                                                               XIN00142
                                                                               XIN00143
        WRITE (6,702)
       FORMAT(5X, DATA HAS BEEN COPIED ON TO DISK 02.)
                                      DETERMINE THE NO. OF HYPERPLANES
                                                                               XINOD144
  702
                                                                               XIN00145
        NH=NC* (NC+1)/2
                                                                                XIN00146
                                                                                XIN00147
        NO = NO IM-1
        RETURN
                                                                                XIN 00 148
        END
```

LINEAR 01

```
LINEAR DISCRIMINANT FUNCTION
CLINEAR
                                                                          LINEAROP
                                                                          LINEAR 93
                                                             SEPT 1972
      WRITTEN BY SAM SHANMUGAM
                                                                           LINEARO4
C
                                                             DEC 1973
      DOCUMENTED BY RJ BOSLEY
                                                                           LINEARD5
C
                                                                           LINEAR 06
      DESCRIPTION OF PROGRAM.
         THIS SUBROUTINE CALLS THE RESPESSION ROUTINE WEIGHT TO GET THE LINEAROY
C
      DISCRIMINATION FUNCTIONS, COMBINES THESE TO OBTAIN A PIECEWISE
                                                                           LINEARTS
C
                                                                           LINEARDS
      LINEAR DISCPIMINANT FUNCTION FOR EACH CATEGORY, AND CLASSIFIES
C
C
      THE TRAINING AND TEST PATTERNS. THIS ROUTINE ALSO OUTPUTS THE
                                                                           LINEAR 10
                                                                           LINEAR 11
C
      RESULTS.
                                                                           LINEAR12
                                                                           LINEAR13
         THE ALGORITHM FOR DETERMINING THE WEIGHT VECTOR FOR SEPARATING LINEAR14
      THEORY.
      THE I AND J-TH CATEGORIES IS W=((U*U*)**-1)*(U*T), WHERE T IS
C
                                                                           LINEAR15
      A VECTOR OF LENGTH NO WITH COMPONENTS OF VALUES EQUAL TO 1.
C
                                                                     FOR
                                                                           LINEAR16
      DETAILS SEE **INTRODUCTION TO STATISTICAL PATTERN RECOGNITION**
                                                                           LINEAR17
                                                                           LINEAR18
       BY FUKUNAGA. ACADEMIC PRESS, 1972.
          THE MATRICES (DIMENSIONED AS ONE DIMENSIONAL IN PGM) HAVE THE
                                                                           LINEAR19
                                                                           LINEAR29
       FOLLOWING STRUCTURES --
                                                          EACH COLUMN
                                                                           LINEAR21
                  --- XTRAIN IS AN NOIM X NTRAIN MATRIX.
          XTRAIN
                                                                           LINEAP22
                    VECTOR IN XTRAIN REPRESENTS ONE TRAINING PATTERN.
                                                                           LINEAR23
                    THE FIRST ENTRY IN EACH COLUMN IS THE CATEGORY NAME
C
 C
                    THE SECOND ENTRY IS THE CONSTANT 1. THE ENTRIES 3
                                                                           LINEAR24
                                                                            LINEAR25
                    TO NOIM ARE THE VALUES OF THE COMPONENTS OF THE
                    PATTERN VECTOR X(J). XTRAIN HAS NIRAIN COLUMNS AND
                                                                           LINEAR26
                                                                            LINEAR27
                    ND+1 = NDIM ROWS.
                                                                            LINEAR28
          XTEST --- XTEST HAS THE SAME CONFIGURATION AS XTRAIN.
                                                                            LINEAR29
                                                                            LINEAR30
                  -- DATA MATRIX U IS USED FOR CALCULATING THE BOUNDARY
                                                                            LINEAR31
                     BETWEEN THE CATEGORIES I AND J. U HAS NO ROWS AND
                                                                            LINEAR32
                                                                            LINEAR33
                     NTR(I)+NTR(J) COLUMNS, AS FOLLOWS---
       ***PATTERNS FROM CATEGORY I********PATTERNS FROM CATEGORY
                                                                            LINEAR34
                                                                           LINEAP 35
                                                                            LINEAR3E
          1
                                                                            LINEAR37
 C
                                                                         -X LINEAR38
 C
                                                                            LINEAR35
 C
                                                                            LINEAR4E
 C
                                                                            FLINFAR41
 C
               U HAS NO ROWS AND NTR(I)+NTR(J) COLUMNS
 C
                                                                            LINEAR45
                                                                            LINFAR43
 C
                                                                            LINEAR4L
        ENTRY POINT.
                                                                            LINEAR4!
 C
                 CALL LINEAR (XTRAIN, XTEST, W. U. DUMMY)
                                                                            LINEAR4F
  C
                                                                             LINEAR47
  C
        INPUT ARGUMENTS.
                                     HATRIX CONTAINING TRAINING PATTERNS
                                                                            LINEAR4
                 XTRAIN
                                                                            LINEAR4
                                     MATRIX CONTAINING TEST PATTERNS
                 YTEST
                                                                             LINFAR5
                                     WEIGHT VECTORS
```

### LINEAR DISCRIMINANT FUNCTION

	<b>u</b>	MATRIX USED FOR CALCULATING THE	LINEARS1
C .	<b>U</b>	BOUNDARY BETHEEN THE CATEGORIES I	LINEAR52
C		AND J.	LINEAR53
Ç	ALIMINA	SCRATCH ARRAY	LINEAR54
C	DUMMY		LINEAR55
C	BADAMETEDS		LINEAR56
C	INTERNAL PARAMETERS.	NUMBER OF CATEGORIES	LINEAR57
C	NG	ADDAY CONTATMING CATEGORY NAMES	LINEAR58
C	NAME	ANIMORD OF TRATMING PATTERNS IN CALL	LINEAR50
000000	NTR(I)	TOTAL NO OF TRAINING VECTORS IN	LINFARSO
C	NIJ	CATEGORIES I ANO J	LINEAR61
C		NUMBER OF TRAINING TEST PATTERNS	LINEAR6?
C	NTRAIN, NTEST	ON DOME THINKY FOR MATRIX U	LINEAR63
C	NCOLU, NRONU	NOTH-1 NO. OF COMP IN WEIGHT VECTOR	LINEAR64
C	NO	ADDAY CONTATNING WEIGHT VEGICES	LINEARSS
C	W	ARRAY CONTAINING ONE WEIGHT VECTOR	LINEARGE
C	ит	CLASSIFICATION LOOP INDEX, =1 FOR	LINEAR67
C	INDEX	TRAINING SET, =2 FOR TEST SET	LINEARAB
00000		BEING CLASSIFIED	LINEAR69
Č		NO. OF PATTERNS TO CLASSIFY	LINEAR70
Č	NPT	CAT FOR WHICH VOTING IS MAXIMUM	LINEAR71
Č	ICLASS	CAT FOR WHICH VOITING IS WINDOW	LINEAR72
C	KOUNT	VOTE TALLY	LINEAR73
Č	KMAX	MAXIMUM VOTE, MAX KOUNT	LINEAR74
Č	IEPROR	CONTINGENCY TABLE	LINEAR75
Č			LINEAR7F
č		2000	LINEAR 7
	SUBROUTINE LINEAR (XTRAI	N, XTEST, H, U, DUMMY)	LINEAR78
C			LINEAR79
č			LINEARAL
•	DIMENSION XTRAIN(1), XTE	ST(1),W(1),U(1),DUHNY(1)	LINEARAL
	DIMENSION TERROR (15,15)	WIK (To) MAULTAN	LINEARSE
	DIMENSION L(100),M(100)		LINEAR8
	COMMON NTRAIN NTEST (ND)	M, NO, NC, NPAIR, NH, NOPT1, NOPT2, NOPT3, NOPT4.	LINEAR8"
	1 NTOT, NPART		LINEAR8
	REAL NAME	ALDERT TOO	LINEAR8:
_	NCAC MANGE	WRITE OUT INPUT PARAMETERS	LINEARB
C	WRITE(6,1401)		LINEARS
	FORMAT (1H1,10X, TINPUT	DATA SUPPLIED BY YOU")	LINEARS
14	WRITE (6, 1492) NTOT NPA	NICH. TS 40 PA	TELTHEARS'
	NII	NATE OF PATTECHOT INTO THE CONTRACT	LINEADO
14	1ERNS WERE USED IN TRAI	NING*/10X, *NDIM=*.13)	LINEAR9
	TEKNO MEKE OBED THE	INITIALIZE NO. OF TRAINING ARRAYS	LINEAR9
C	00 4 1-4 NC		LINEAR9
	DO 1 J=1,NC		LINEARD
_1	0=(U) \$1N	SET UP NAME OF FIRST CATEGORY	LINEAR9
C		관측하다 TTP 회사 그 사는 사람들은 그 사람들에 가져 보았다.	
	J=1		LINEARS
	NAME(1)=XTRAIN(1)	GO THRU ALL THE TRAINING PATTERNS	LINEARG
C	AA PITA NYORIN	되는 이 문화가 되었다. 그 모든 그 그 등으로 보고 있다면요?	LINEARO
	DO 3 I=1.NTRAIN	[[[[하다 : 1 ] [[살아보다] 그는 하나님 하는 종종의 말을 때 말라고 되어 있었다.	

```
LINEARO1
      I1 = (I-1) * NOIM+1
                                   SKIP IF WE HAVE THIS CATEGORY NAME
                                                                            LINEARDS
C
                                                                            LINEARO3
      IF (NAMF(J) .EQ.XIRAIN(I1)) GO TO 2
                                    OR. SET UP A NEW CATEGORY
                                                                            LINEARON
C
                                                                            LINEAR05
      J=J+1
                                                                            LINEAR06
                                    GET THE NEW NAME
                                                                            LINEAR 07
      NAME (J) =XTRAIN(I1)
                                                                            LINEAP OR
                                    COUNT THE NUMBER IN THIS CATEGORY
                                                                            LINEAROS
      NTR(J)=NTP(J)+1
 2
                                                                            LINEAR10
      CONTINUE
 3
                                    WRITE OUT NO. OF TRAINING AND TEST
                                                                            LINEAR11
C
                                                                            LINEAR12
                                    PATTERNS AND THE NO. OF CATEGORIES
C
                                                                            LINEAR13
                                    FOUND
C
                                                                            LINEAR14
      WRITE(6,1403) NTRAIN, NTEST, J
 1403 FORMAT (10x, NUMBER OF TRAINING PATTERNS USED=*, 14/10x, NUMBER OF LINEARIS
     11FST PATTERNS USED=", 14/10X, NUMBER OF GROUND TRUTH LABELS FOUND="LINEAR16
                                                                             LINEAR17
     (1, 13)
                                                                             LINEAR18
                                    WRITE OUT THE NO. OF CATS SPECIFIED
C
                                                                             LINEAR19
                                    BY THE USER
C
                                                                            LINEAR20
       WRITE (6, 1404) NC
 1404 FORMAT(/10x, NUMBER OF GROUND TRUTH LABELS SPECIFIED = ,13)
                                                                             LINEAR21
                                                                             LINEAR22
       WRITE(6.1411)
                                                                             LINFAR23
 1411 FORMAT (1H1,5X, SUMMARY OF WEIGHT VECTORS 1//)
                                                                             LINEAR24
                                    FIND THE HYPERPLANES WHICH SEPARATE
                                                                             LINEAR25
CCC
                                    CATEGORIES I AND J. WHERE I GOES FROM LINEAR?
                                                                             LINEAR27
                                    1 TO NO AND J GOES FROM I+1 TO NO.
C
                                                                             LINEAR28
C
                                                                             LINEAR29
       IWCOL=0
                                                                             LINEAR30
       DO 10 I=1,NC
                                                                             LINEAR31
       IPLUS1=1+1
                                                                             LINEAR32
       DO 10 J=IPLUS1,NC
                                                                             LINEAR33
                                    CHECK FOR FINAL LOOP
C
                                                                             LINEAR34
       IF (J.GT.NC) GO TO 868
                                                                             LINEAR35
                                    INCREMENT COLUMN INDEX
 C
                                                                             LINEAR36
       INCOL=INCOL+1
                                                                             LINEAR37
       ISUM = 0
                                                                             LINEAR38
                                    SET UP MATRIX U FOR CAT I AND J
 C
                                                                             LINEAR39
       DO 9 K=1.I
                                                                             LINEAR40
  9
       ISUM=ISUM+NTP(K)
                                     FIND THE COL IN XTRAIN WHERE THE
                                                                             LINEAR41
 C
                                     PATTERNS THAT BELONG TO I AND J BEGIN LINEAR42
 C
                                                                             LINEAR43
       IWBEG=ISUM-NTR(I)
                                                                             LINEAR44
       ISUM=0
                                                                             LINEAR45
       DO 8 K=1.J
                                                                             LINEAR46
       ISUM=ISUM+NTR(K)
                                                                             LINEAR47
       JWBEG=ISUM-NTR(J)
                                                                             LINEAR48
 C
                                                                             LINEAR49
                                     GET ENTRIES FROM XTRAIN AND PUT INTO
 C
                                                                             LINEAR50
                                     THE MATRIX U
 C
```

### LINEAR DISCRIMINANT FUNCTION

			LINEAR51
			LINEAR52
1	NI=NTR(Î)		LINEAR53
	NJ=NTR(J)		LINFAR54
	NIJ=NTR(I)+NTR(J)	GO THRU EACH TRAINING PATTERN IN CAT	
,		CO THEO ENCH LEGITION LANGE THE OWN	LINEAR56
	DO 7 NCOLU=1,NI	THORN AND TON YERATM	LINEAR57
,		INDEX COL FOR XTRAIN	LINEAR59
	NCOLXT=NCOLU+IWBFG	GO THRU EACH COMP IN VECTOR	LINEAR59
;		GO THRU EACH COMP IN VEGTOR	LINEARSO
	DO 6 NRONU=1.NO	Un Puntve	LINFAR61
		SET UP INDEXS	LINEAR62
	NPOWX=NPOWU+1		LINEAR63
	NRCU = (NCOLU-1) *ND+NPOWU		LINEAR64
	NRCX=(NCOLXT-1)*NOIM+NROWX	TRANSFER PATTERN TO U FROM XTRAIN	LINEAR65
		TRANSPER PATIENT TO OTHOR ATTACH	LINEAR66
6	U(NRCU) = XTRAIN(NRCX)		LINEAR67
7	CONTINUE	THE CAME FOR CATECORY !	LINEAR63
<b>;</b>		DO THE SAME FOR CATEGORY J	LINEAR69
;		GO THRU EACH PATTERN IN CAT J	LINEAR70
	ກດ 19 NN=1,NJ		LINEAR71
		SET UP COL INDEX	LINEAR72
	NCOLU=NI+NN		LINEAR73
	NCOLXT=JNSEG+NN		LINEAR74
	DO 18 NROWU=1,ND		LINEAR75
		SET UP ROW INDEX	LINEAR75
	NROWX=NROWU+1	가는 것이 많아 있는 생님, 유럽는 살이 되었다면 함께	LINEAR77
et garage	NRCU=(NCOLU-1) *ND+NROWU		LINEAR78
	NRCX=(NCOLXT-1) *NOIM+NROWX	TRANSFER THE VECTOR IN XTRAIN TO U	LINEAR79
		TRANSFER THE VECTOR IN VINCET	LINEAR80
		AND CHANGE THE SIGN	LINEAR81
18	U(NRCU)=(-1.0)*XTRAIN(NRCX)	이 나는 그 그 사람들이는 그 그림을 하다고 했다.	LINEAR82
19	CONTINUE	CALL THE REGRESSION ROUTINE	LINEAR83
			LINFAR84
	CALL WEIGHT (U.DUMMY, WT, ND, N	GET WEIGHT VECTOR FOR CATS I AND J	LINEAP85
		REL METRUL AFRICK TOWN AND T	- LINEAR86
	DO 40 IROWW=1,ND	INDEX THE VECTOR INTO W ARRAY	LINEAR87
<b>)</b>		INDEX THE ACCIDE THIS ILL WALL	LINEAR85
	IRCH= (IWCOL-1) *ND+IROWW		LINEAR89
40	W(IRCW)=WT(IROWW)	WRITE OUT THE WEIGHT VECTOR	LINEARSO
<b>)</b>		MKILE OOL THE METOLICA	LINEAR91
	WPITE(6,100) I,J		LINEAR92
	IQCW1=(IWCOL-1)+NO+1	이 그렇게 보는 것 같아. 네이를 하다고 수도 말을 모르는	LINEAR93
	IRCW2=IWCOL*ND		LINEAR94
	WRITE(6,101) (W(IRCW), IRCW	TRUMI, I PUME A TENDE CATEGORIES . I3.3H	
100	FORMAT (2X,44HTHE WEIGHT VE	TOR FOR SEPARATING CATEGORIES . 13,3H	LINEAR96
	(13)	그는 민준이 이번 이번에는 경기 가격 사람들 때문에 제한 살길	LINEAR97
101	FORMAT ((1X,10F12.5))	WIND OUT THE METCHE MECTOD	LINEAROR
;	엄마님들 그 그렇게 이 이렇게 이렇게 얼마나 나를 다	PUNCH OUT THE WEIGHT VECTOR	LINEAR99
	WOITE (43, 100) I,J		LINEAROD
	WRITE (43, 1761) (H(IPCH), IR	UM#1K0M1• TKOMC1::::::::::::::::::::::::::::::::::::	
	ran ing alam ing terminan ngan salam ang ang manahalan ing arter na milang ang ang ang ang terminan ng kalaman	on the contract of	

#### LINEAR DISCRIMINANT FUNCTION

20.415

02-09-74

C

LINEAR01 FORMAT((4X,6F12.5)) LINEAROS 1761 CONTINUE 868 LINEAR 03 CONTINUE LINEAR94 10 LINEAR 05 LINEAROS BEGIN CLASSIFICATION LINFAR 117 LINEARO8 GO THRU FIRST FOR TRAINING PATTERNS LINEARU9 C THEN FOR TEST PATTERNS LINEARIO C DO 67 INDEX=1.2 LINEAR11 WRITE HEADING LINEAR12 IF ((INDEX.ED.1).AND.(NOPT3.NE.0)) WRITE(6,1498) LINEAR13 IF ((INCEX.ED.2).AND.(NOPT4.NE.0)) WRITE (6,1499) LINFAR14 1498 FORMAT (1H1.5X, \*CLASSIFICATION OF TRAINING PATTERNS\*) 1499 FORMAT (1H1, 10X, \*CLASSIFICATION OF TEST PATTERNS\*) LINEAR15 INITIALIZE CONTINGENCY TABLE FOR ALL LINEAR16 LINEAR17 CATEGORIES C LINEAR18 DO 78 IMN=1.15 LINEAR19 00 78 JMN=1-15 LINEAR20 IERROR (IMN, JMN) = 0 LINEAR21 78 WRITE HEADING LINEAR22 C IF ((INDEX.EQ.1).AND.(NOPT3.NE.0)) WRITE(6,1500) LINEAR23 IF ((INDEX.EQ.2).AND. (NOPT4.NE.0)) WRITE (6,1500) 1500 FORMAT(///2x, PATTERN NO. \*, 5x, TRUE CAT\*, 6x, \*ASSIGNED CAT\*, 9x, \*VOLINEAR24 175 1 LINEAR26 SET NO. OF PATTERNS TO CLASSIFY LINEAR27 C IF (INDEX.FQ.1) NPT=NTPAIN LINEAR28 IF (INDEX . EQ . 2) NPT=NTEST LINEAR29 RETURN IF NO TEST SET LINEAR30 C IF ((INDEX.EQ.2).AND. (NTEST.EQ.0)) RETURN GO THRU EACH PATTERN TO BE CLASSIFIED LINEAR31 LINEAR 32 C DO 66 III=1,NPT LINEAR33 GO THRU FACH COMPONENT AND PULL OUT LINEAR34 C THE TRAINING VECTORS FROM CORE LINEAR35 C DO 55 NOUM=1.ND LINEAR35 LINEAR37 IXROW=NOUM+1 IXIII=(III-1) \*NDIM+IXROW LINEAP 38 IF(INDEX.EQ.1) U(NDUM)=XIRAIN(IXIII) LINEAR30 OTHERWISE READ TEST VECTORS FROM 02 LINEAR 40 CONTINUE 55 LINEAR41 IF (INDEX.EQ.2) READ(2) DUMMY1, DUMMY2, CUMMY3, (U(NOUM), NOUM=1, NO) C LINEAR42 LINEAR43 KMAX=-20 GO THRU EACH CAT FOR VOTING LINEAR4" C 00 65 IIC=1.NC LINFAR45 KOUNT=0 LINEAR46 LINEAR47 LOCATE THE HYPERPLANE THAT SEPARATES C CATS IIC AND JUG. THE SIGN OF THE HEIGHT VECTORS IS CHANGED DEPENDING LINEAR4º C LINEAR45 C LINEAR50 C UPON WHETHER OR NOT JJC.GT.IIC

### 02-03-74 20.415 LINEAR DISCRIMINANT FUNCTION

```
LINEARS
     DO 64 JJC=1,NC
                                                                             LINEAR5
      IF(JJC.EQ.IIC) GO TO 63
                                                                             LINEARS
      IF (JJC.GT.IIC) GO TO 50
                                                                             LINEA 95
      IF (JJC.LT.IIC) GO TO 41
                                                                             LINEAR5
      CONTINUE
50
                                                                             LINEARS
                                    SET PARAMETERS
                                                                             LINEAR5
      SIGN=1.0
                                                                             LINEAR5
      ISUM=0
                                                                             LINEAR5
      IS=IIC-1
                                                                             LINEARB
      IF(IS.E9.0) GO TO 53
                                                                             LINEAR5
      DO:51 KS=1.IS
                                                                             LINEARS
      ITERM=NC-KS
                                                                             LINEAR6
      ISUM=ISUM+ITERM
 51
                                                                             LINEARS
 53
      CONTINUE
                                                                             LINEARS
      NCOLW=ISUM+JJC-IIC
                                                                             LINEA96
                                    THEN GO TO VOTE CALCULATIONS
Ċ
                                                                             LINEARS
      GO TO 45
                                                                             LINEARS
      CONTINUE
 41
                                    SET PARAMETERS FOR SIGN CHANGE
                                                                             LINEAR6
                                                                             LINEAR7
      ISUM=0
                                                                             LINEAR7
      SIGN=-1.0
                                                                              LINEAR7
      IS=JJC-1
                                                                             LINEAR7
      IF (IS.EQ.0) GO TO 43
                                                                             LINEAR7
      DO 42 KS=1.IS
                                                                              LINE427
      ITERM=NC-KS
                                                                              LINEAR7.
      ISUM=ISUM+ITERM
 42
                                                                              LINEAR7
      CONTINUE
 43
                                                                              LINEART
      NCOLW=ISUM+IIC-JJC
                                                                              LINEAR7
      CONTINUE
 45
                                                                              LINEARS
C
                                                                              LINEARS
                                     COMPUTE XTRAIN ** W(NCOLW)
C
                                                                              LINEAR8
       SUM=0.0
                                                                              LINEAR8
       DO 52 IWPOW=1,ND
                                                                              LINEAP8
       IXRON=IWROW+1
                                                                              LINEAR8
       IWRCW=(NCOLW-1) *NO+IWROW
                                                                              LINEAR8
       SUM=SUM+ (U(IWROW)) * (W(IWRCW)) * (SIGN)
                                                                              LINEARS
       CONTINUE
 52
                                                                              LINEAR8
       IVOTE=0
                                                                              LINEARA
                                     VOTE POSITIVE IF SUN .GT. ZERO
                                                                              LINEAR9
       IF (SUM.GT.0.0) IVOTE=1
                                                                              LINEAR9
                                     ELSE VOTE NEGATIVE
C
                                                                              LINEAR9
       IF (SUM.LT.0.0) IVOTE=-1
                                                                              LINEAR9
       CONTINUE
 63
                                     IF SAME CATEGORY, DONT VOTE
                                                                              LINEAR9
 C
                                                                              LINEAR9
       IF (JJC.EQ.IIC) IVOTE=0
                                                                              LINEAR9
                                     TALLY THE COUNT
                                                                            . LINEARS
       KOUNT=KOUNT+IVOTE
  64
                                     DETERMINE THE CAT FOR WHICH VOTE IS
                                                                              LINEAR9
 C
                                                                              LINEAR9
                                     MAXIMUM
                                                                              LINEARD
       IF (KOUNT. GT. KMAX) : ICLASS=IIC
```

```
LINEARD.
                                    RESET MAX COUNT
C
                                                                             LINEARD
      IF (KOUNT.GT.KMAX) KMAX=KOUNT
                                                                             LINEARU
      CONTINUE
 65
                                                                             LINEARN
C
                                    GET THE RESULTS AND OUTPUT THEM
                                                                             LINEARD!
C
                                                                             LINEARO.
C
                                                                             LINEARD
      III1=(III-1)*NDIM+1
                                                                             LINEARD
      IF (INDEX.FO.1) TOAT=XTRAIN(III1)
                                                                             LINEARD
      IF(INDEX.FO.2) IGAT=DUMMY1
                                     HRITE RESULTS FOR THIS PATTERN VECTOR LINEARI
      IF((INDEX.EQ.1).AND.(NOPI3.NE.0).AND.(KMAX.EQ.0)) WRITE(6.1501)IIILINFAR1
                                                                             LINEAR1.
     1.TCAT
      IF ((INDEX.EQ.2).AND.(NOPT4.NE.0).AND.(KMAX.EQ.0)) WRITE(6,1502)IIILINEAR1
                                                                              LINEAR1
      1, TCAT
      IF ((INDEX.EQ.1).AND.(NOPT3.NE.0).AND.(KMAX.GT.0)) WRITE (6.1502) IIILINEAR1
                                                                              LINEAR1
      1, TCAT, NAME (ICLASS), KMAX
      IF ((INDEX.EG.2). AND. (NOPT4.NE.0). AND. (KMAX.GT.0)) WRITE (6, 1502) I IL INEAR1
                                                                              LINEAR1
      1,TCAT, NAME (ICLASS), KMAX
                                                                              LINEAR1
       FORMAT(6X, I3, 11X, A5, 10X, 14HNOT CLASSIFIED)
 1501
                                                                              LINEARS
      FORMAT (6X, 13, 11X, A5, 10X, A5, 12X, 13)
 1502
                                                                              LINEAR2
       DO 71 ITCAT=1.NC
                                                                              LINEARS
       IF (TCAT.EQ.NAME(ITCAT)) JTCAT=ITCAT
                                                                              LINEARS
       CONTINUE
 71
                                                                              LINEAR2
       ITCAT=JTCAT
                                                                              LINEARZ
                                     UPDATE THE CONTINGENCY TABLE
       IF (KMAX.GT.0) IERROR (ITCAT. ICLASS) = IERROR (ITCAT. ICLASS) +1
                                                                              LINEARS
 72
                                                                              LINEAR2
       CONTINUE
 66
                                                                              LINEAR2
                                     WRITE OUT THE HEADING
                                                                              LINEAR2
       IF (INDEX.EQ.1) WRITE (6,721)
                                                                              LINEAR3
       IF (INDEX.EQ.2) WRITE(6,722)
       FORMAT(1H1,15X, *CONTINGENCY TABLE FOR TRAINING PATTERNS*)
                                                                              LINEAR3
 721
       FORMAT(141,15X, CONTINGENCY TABLE FOR TEST PATTERNS*)
                                                                              LINEAR3
  722
                                                                              LINEAR3
       WRITE (6,723)
                                                                              LINEAR3
       FORMA T(4X, *TRUE* /2X, *CATEGORY*)
  723
                                      WRITE OUT THE CONTINGENCY TABLE
                                                                              LINEAR3
                                                                              LINEAR3
       DO 74 ITCAT=1 NG
                                                                              LINEAR3
       WRITE (6,724) NAME (ITCAT), (IERROR (ITCAT, ICLS), ICLS=1,NC)
  74
                                                                              LINEAR3
       FORMAT(//3X, A6, 15(4X, I3))
  724
                                                                              LINEAR3
                                     LIST THE CATEGORIES
 C
                                                                              LINEAR4
       WRITE (5.725) (NAMF (ICLA), ICLA=1,NC)
                                                                              LINEAR4
       FORMAT(//11X, 15(1X, 46))
  725
                                                                              LINEAR4
       WRITE (6.726)
                                                                              LINEAR4
       FORMATI/15X. ASSISNED CATEGORY .)
  726
                                                                             LINEAR4
       CONTINUE
  67
                                                                              LINEAR4
       RFTURN
                                                                               LINEAR4
       END
```

WEIGHTO:

(

··.

```
GET THE WEIGHT VECTOR
CWEIGHT
                                                                            WEIGHTO
                                                                            WEIGHTO
                                                              SEPT 1972
      WRITTEN BY SAM SHANMUGAM
C
                                                                            WEIGHTO
                                                                   1973
                                                               DEC
      DOCUMENTED BY RJ BOSLEY
C
                                                                            WEIGHTON
C
                                                                            WEIGHTO:
      DESCRIPTION OF PROGRAM.
C
         GIVEN A MATRIX U CONTAINING PATTERNS OF CATEGORY I AND J.
                                                                             WEIGHTO,
C
      THIS ROUTINE FINDS A HYPERPLANE TO SEPARATE THESE PATTERNS. THE
                                                                            WEIGHTO
C
                                                                             WEIGHTO
      WEIGHT VECTOR DEFINING THE HYPERPLANE IS GIVEN BY
C
                                                                             WEIGHT1
                    WT = ( (UU*)**-1)*(U*T)
                                                                             WEIGHT1
                          IS THE WEIGHT VECTOR
C
      WHERE
               WT
                          IS A COLUMN VECTOR WHOSE COMPONENTS ARE +1 S
                                                                             WEIGHT1
               T
                                                                             WEIGHT1
                            THE LENGTH OF THE PATTERN VECTORS, AND
               ND
                          IS THE NUMBER OF PATTERNS FROM CAT I + NUMBER
                                                                             WEIGHT1
               NIJ
                                                                             WEIGHT1
                          OF PATTERNS FROM CATEGORY J
C
      THE DATA MATRIX U. USED FOR CALCULATING THE BOUNDARY BETWEEN THE
                                                                             WEIGHT1
C
                                                                             WEIGHT1
      CATEGORIES I AND J. IS FORMED AS FOLLOWS ---
C
                                                                             WEIGHT1
       ***PATTERNS FROM CATEGORY I************ FROM CATEGORY J -*** WEIGHT1
C
C
                                                                          -1 WEIGHT2
C
                                                                             WEIGHT?
C
                                                                             WEIGHT2
C
                                                                          -X WEIGHT2
                                               - X :
C
                                                                             WEIGHT2
C
                                                                             WEIGHTS
C
                                                                            ¥WEIGπT2
              U HAS NO ROWS AND NIJ COLUMNS .
C
                                                                             WEIGHT2
C
                                                                             WEIGHTS
C
                                                                             WEIGHT?
                     CALL WEIGHT (U, DUMMY, NT, NG, NIJ)
C
                                                                             WEIGHT3
C
                                                                             WEIGHT3
       INPUT ARGUMENTS.
                                     MATRIX CONTAINING PATTERNS OF
                                                                             WEIGHT3
 C
               U
                                                                             WEIGHT3
                                     CATEGORIES I AND J
 C
                                                                             WEIGHT3
                                     DUMMY ARRAY USED FOR MINV
                DUMMY
 C
                                                                             WEIGHT3
                                     LENGTH OF PATTERN VECTORS IN U
 C
                NO
                                                                              WEIGHT3
                                     NUMBER OF PATTERNS FROM CAT I AND J
                NIJ
 C
                                                                              WEIGHT3
 C
                                                                              WEIGHT3
       OUTPUT ARGUMENT.
                                     WEIGHT VECTOR DEFINING THE HYPERPLANE WEIGHTS
 C
                                     SEPARATING PATTERNS OF CAT I AND J
                                                                              WEIGHT4
 Ċ
                                                                              WEIGHT4
 C
                                                                              WEIGHT4
       SUBPROGRAMS REQUIRED.
 C
                                     MATRIX INVERSION PGM FROM IBM SSP
                                                                              WEIGHT4
                MINV
                                                                              WEIGHT4
 C
                                                                              WEIGHT4
       INTERNAL PARAMETERS.
 Ċ
                                                                              WEIGHT4
                                      SCRATCH ARRAYS USED BY MINV
 Ċ
                L,M
                                                                              WEIGHT4
                                     DETERMINANT OF DUMHY FROM HINV
 CCC
                D
                                                                              WEIGHT4
                                     ROW. OR COMPONENT. INDEX FOR WT
                IROWW
                                                                              WEIGHT4
                                     INDEX FOR A VECTOR IN DUMMY
                IDJD
                                      INDEX FOR A VECTOR IN DUMMY AFTER IT
                IROWWK
```

•		HAS BEEN INVERTED BY MINV	WEIGHT51
C			WEIGHT52
C			WEIGHT53
·	SUBROUTINE WEIGHT (U, DUMMY, W)	(LIN, CM, T	WEIGHT54
С	30580011112 11220111010		WEIGHT55
· ·	DIMENSION U(1) . DUMMY(1) . WT(	100)	WEIGHT56
	DIMENSION L(100), M(100)		WEIGHT57 WEIGHT58
C		SET UP MATRIX DUMMY=U*U*	WEIGHT59
č		GO THRU EACH COMPONENT	WEIGHT60
	00 15 ID=1.ND		WEIGHT61
	00 15 JD=1,ND		WEIGHT62
	SUM=0.0		WEIGHT63
C		GO THRU EACH VECTOR	WEIGHT64
•	DO 14 K=1.NIJ		WEIGHT65
	IUK=(K-1)*ND+ID		WEIGHT66
	JOK=(K-1) *ND+JD		WEIGHT67
C		FIND U*U*	WEIGHT68
14	SUM=SUM+U(IOK)*U(JOK)	医三角质 计制度图片 医阿克氏囊膜 化二角原基 原形的	WEIGHT69
	IDJD=(JD-1)*ND+ID	STORE IT IN DUMMY FOR INVERSION	WEIGHT70
C		SINKE IT IN DOUGHT LOK THAT STOR	WEIGHT71
	NUZ=(OLCI) YMMUC		WEIGHT72
15	CONTINUE	FIND THE INVERSE OF U*U*	WEIGHT73
C		FIND THE THACKSE OF CO.	WEIGHT74
	CALL MINY (DUMMY , NO , D , L , M)		WEIGHT75
	00 30 K=1,ND		WEIGHT76
	SUM=0.0	아마니다 그리는 아이지를 모든 아이들이 말라냈다.	WEIGHT77
	00 25 KK=1,NIJ	COMPUTE U*T	WEIGHT78
C	4 1 5 1 5 1 5		WEIGHT79
	KKK=(KK-1)*NT+K		WEIGHT80
25	SUM=SUM+U(KKK)	STORE IT IN U(K,1),K=1,ND	WEIGHT81
C	U(K)=SUM		WEIGHT92
30	0(K)-300	COMPUTE THE WEIGHT VECTOR	WEIGHT83
Ç		W(IROWW, NCOL), IROWW=1, ND	WEIGHT84
C	DO 40 IROWW=1.ND	그 이 [2호] 그렇게 느 하지 않는 사람들은 사람	WEIGHT95
	SUM=0.0	이 그 양생들은 번째 이 기를 막지는 나는데 하고 있다. 벽	WEIGHT 86
	DO 35 K=1,ND		WEIGHT87
	IROWHK=(K-1)*NO+IROWW		WEIGHT98
35	SUM=SUM+DUMMY(IPOWWK) *U(K)	~ 20kg : - 10 ( <b>(</b> 5 ) 140 (14 kg) - 14 kg) 전 12 <u>(</u> 2 12 kg) - 14	WEIGHT89
C		STORE IT IN MT ARRAY AND RETURN	WEIGHT90 WEIGHT91
Ŭ40	WT (IROWW) =SUM		WEIGHT92
•	RETURN	실하면 보다 이 <b>있</b> 다. 그는 네이트 프로그램 가는 그를 보다는 보다	WEIGHT93
	END	병하다. 회장하다 중요한 교육은 본 학자들은	METOW132

APPENDIX V

## Glossary and Index to Remotely Sensed Image Pattern Recognition Concepts\*

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Abstract—The purpose of the glossary is to state in the simplest possible way the general meaning or word usage for many of the terms in image pattern recognition. There is no intent to provide definitive statements for terms such as "resolution" but rather only statements about the general nature of what resolution is. There is no intent to provide mathematical formulas involving integrals or derivatives in any of the statements. Those who need the mathematics can get it from technical papers or texts.

The glossary is designed to be read by those generally unfamiliar with the area and provide for them an overall perspective. The organization approaches that of programmed learning material and can be smoothly (I hope)

read from beginning to end. Those needing to look up a specific term can do so via the index.

There is some overlap of terms in this glossary with those glossaries or definitions in radiometry and aerial photography. There is no intent that the way the terms are described here replace the way they are described in those glossaries and definitions. The overlap is provided here so that the reader can get a perspective of a cluster of terms frequently used in our field. The perspective is intended to start from what the image concept is through the recording of an image by some sensor, the possible conversion of image format and the simple analog or more complex digital processing which must be done on the imagery. In short, the perspective is one of image pattern recognition.

- 1. An Image is a spatial representation of an object, scene, or another image. It can be real or virtual as in optics. In pattern recognition, image usually means a recorded image such as a photograph, map, or picture. It may be abstractly thought of as a continuous function I of two variables defined on some bounded region of a plane. When the image is a photograph, the range of the function I is the set of grey shades usually considered to be normalized to the interval [0, 1]. The grey shade located at spatial coordinate (x, y) is denoted by I(x, y) and is usually proportional to the radiant energy in the electromagnetic band to which the photographic sensor is sensitive. When the image is a map, the range of the function I is a set of symbols or colors, and the symbol or color located at spatial coordinate (x, y) is denoted by I(x, y). A recorded image may be in photographic, video signal, or digital format.
- 2. The grey shade or grey tone is a number or value assigned to a position (x, y) on an image. The number is proportional to the integrated output, reflectance, or transmittance of a small area, usually called a resolution cell or pixel, centered on the position (x, y). The grey shade can be measured as or expressed in any one of the following ways:
  - (1) transmittance
  - (2) reflectance
  - (3) a coordinate of the ICI color coordinate system

\* The glossary was prepared as the report from the definitions and standards subcommittee, Automatic Image Pattern Recognition Committee of Electronic Industries Association.

† I would like to acknowledge the helpful suggestions, comments and corrections which many of my colleagues made. Particular thanks are due to R. Asendorf, B. Bulluck, L. Kirvida, P. Pryor, A. Rosenfeld, B. Scheps, R. Swonger, S. Viglione and R. Zaputowycz.

- (4) a coordinate of the tristimulus value color coordinate system
- (5) brightness
- (6) radiance
- (7) luminance
- (8) density
- (9) voltage
- (10) current.
- 3. A photograph is a "hard copy" pictorial record of an image formed by a sensor. The photograph is usually recorded on some type of phososensitive emulsion. It can be either reflective, as is a paper print, or transmissive, as is a transparency. It is usually two-dimensional and its reflectance or transmittance, (either monochromatic or polychromatic) varies as a function of position. If it is a multi-colored image (polychromatic), it can be either natural color where the colors are similar to the original, or false color where the colors of the photograph are radically different from the original. The sensor used to form the image may be any type such as an optical camera with or without spectral filtration, infrared optical-mechanical scanners, TV systems, radars, or sonic sensors, etc. The type of sensor recording the image and spectral region the sensor is sensitive to, should always be indicated when referring to a photograph.

1

- 4. A map is a representation, of physical and/or cultural features (natural, artificial or both) of a region (such as the sky) or a surface such as that of the earth or a planet. It indicates by a combination of symbols and colors those regions having designated category identifications. Very often ground truth and/or decision rule category assignments are displayed by maps. A photograph with limited symbolism and annotation is often called a photo-map.
- 5. The radiant intensity of a point object is a measure of the radiant power per steradian radiated or reflected by an object. In general, radiant intensity is a function of the nature of the object, the viewing angle, spectral wavelength and band-width.
- 6. The reflectance or reflection coefficient is the ratio of the energy per unit time per unit area (radiant power density) reflected by the object to the energy per unit time per unit area incident on the object. In general, reflectance is a function of the incident angle of the energy, viewing angle of the sensor, spectral wavelength and bandwidth, and the nature of the object.
- 7. The transmittance or transmittance coefficient is the ratio of the energy per unit time per unit area (radiant power density) transmitted through the object to the energy per unit time per unit area incident on the object. In general, transmittance is a function of the incident angle of the energy, viewing angle of the sensor, spectral wavelength and bandwidth, and the nature of the object.
- 8. The density of an (x, y) position on a photograph is a measure of the light absorbing capability of the silver or dye deposited on that position. It is defined by the logarithm of the position's reciprocal transmittance. The density measured should be specified as to whether it is specular or diffuse.
- 9. Densitometry is the field devoted to the measurement of optical image densities on film or print grey shades usually caused by the absorption of reflection of light by developed photographic emulsion.
- 10. A densitometer is a device used to measure the average image density of a small area of specified size on a photographic fransparency or print. The measurement may be a

meter reading or an electronic signal. When the small area is smaller than a few hundred microns square, the instrument is called a *micro-densitometer*.

- 11. The contrast for a point object against its background can be measured by: (1) its contrast ratio, which is the ratio between the higher of object transmittance or background transmittance to the lower of object transmittance or background transmittance; (2) its contrast difference, which is the difference between the higher density of object or background to the lower density of object or background; (3) its contrast modulation, which is the difference between the darker of object or background grey shade and the lighter of object or background grey shade and background grey shade.
- 12. Resolution is a generic term which describes how well a system, process, component or material, or image can reproduce an isolated object or separate closely spaced objects or lines. The limiting resolution, resolution limit or spatial resolution is described in terms of the smallest dimension of the target or object that can just be discriminated or observed. Resolution may be a function of object contrast, spatial position as well as element shape (single point, number of points in a cluster, continuum, or line etc.).
- 13. The resolving power of an imaging system, process, component or material is a measure of its ability to image closely spaced objects. The most common practice in measuring resolving power is to image a resolving power target composed of lines and spaces of equal width. Resolving power is usually measured at the image plane in line pairs per millimeter, i.e. the greatest number of lines and spaces per millimeter that can just be recognized. This threshold is usually determined by using a series of targets of decreasing size and basing the measurement on the smallest one in which all lines can be counted. In measuring resolving power the nature of the target (number of lines and their aspect ratio), its contrast and the criteria for determining the limiting resolving power must be specified.
- 14. Acutance is a measure of the sharpness of edges in a photograph or image. It is defined for any edge by the average squared rate of change of the density across the edge divided by the total density difference from one side of the edge to the other side of the edge.
- 15. The spread function of an image system, process, component, or material describes the resulting spatial distribution of grey shade when the input to the system is some well defined object much smaller than the width of the spread function. If the input to the system is a line, the spread function is called the *line spread function*. If the input to the system is a point, the spread function is called the *point spread function*.
- 16. The Modulation Transfer Function of an imaging system or component measures the spatial frequency modulation response of the system or component. As an imaging system or component processes or records an image, the contrast modulation of the processed or recorded image is different from the input image. In fact, there is always a spatial frequency beyond which the contrast modulation of the processed or recorded (output) image is smaller (worse) than the contrast modulation of the input image. The modulation transfer function can be thought of as a curve indicating, for each spatial frequency, the ratio of the contrast modulation of the output image to the contrast modulation of the input image. It is formally defined as the magnitude of the Fourier transform of the line spread function of the imaging system or component.
- 17. A resolution cell is the smallest most elementary areal constituent of grey shades considered by an investigator in an image. A resolution cell is referenced by its spatial coordinates. The resolution cell or formations of resolution cells can sometimes constitute the basic unit for pattern recognition of image format data.

18. A digital image, or digitized image, or digital picture function of an image is an image in digital format and is obtained by partitioning the area of the image into a finite two-dimensional array of small uniformly shaped mutually exclusive regions, called resolution cells, and assigning a "representative" grey shade to each such spatial region. A digital image may be abstractly thought of as a function whose domain is the finite two-dimensional set of resolution cells and whose range is the set of grey shades.

19. A picture element or pixel or pel is a pair whose first member is a resolution cell and whose second member is the grey shade assigned by the digital image to that resolution cell. Sometimes picture element, pixel, or pel refer only to the grey shade or grey shade

n-tuple in a resolution cell.

20. A multi-image is a set of images, each taken of the same subject at different times, or from different positions, or with different sensors, or at different electromagnetic frequencies, or with different polarizations. Although there is a high degree of information redundancy between images in a multi-image set, each image usually has information not available in any one of or combinations of the other images in the set.

21. A multi-digital image is a multi-image in digital form. It can be, for example, a set of digital images obtained from the images in a multi-image. A multi-digital image is often called a multi-image for short when it is understood from context that digital images are

involved.

22. A flying spot scanner is a device used to rapidly convert image data from photographic format to electronic video signal format. Normally, the scanner directs an electron beam across the face of a cathode ray tube (CRT) in a TV-like raster. The photographic transparency is placed in front of the CRT (either directly or through some optics) and the light coming from the CRT is passed through it. The modulated light beam is detected by a photomultiplier or other photo detector and amplified to a usable video signal level.

23. A scanning densitometer is a device used to convert image data from transparency photographic format to electronic video signal format. Usually, the photographic transparency is placed on a glass cylinder which rotates and slowly translates. A fine beam of light is focused on the transparency, passed through it, and is detected by a photo-multiplier where it is amplified to a usable video signal. The scanning densitometer is a much slower conversion device than the flying spot scanner. However, this disadvantage is compensated

by its fine resolution capability of a few microns.

24. The vidicon is an imaging vacuum tube having a photosensitive surface and is a means of converting image data from instantaneous radiance format to electronic video signal format. The scene being viewed is imaged on the photosensitive surface which can be scanned by an electron beam generating a signal whose amplitude corresponds to the radiant intensity focused on the surface at each point. This signal is called a video signal and may be amplified to any desired level.

25. A video image is an image in electronic signal format capable of being displayed on a cathode ray tube screen. The video signal is generated from devices like a vidicon or flying spot scanner which converts an image from photographic form to video signal form by scanning it line by line. The video signal itself is a sequence of signals, the ith signal repre-

senting the ith line of the scanned image.

26. Registering is the translation-rotation alignment process by which two images of like geometries and of the same set of objects are positioned coincident with respect to one another so that corresponding elements of the same ground area appear in the same place on the registered images. In this manner, the corresponding grey shades of the two images at any (x, y) coordinate or resolution cell will represent the sensor output for the same object over the full image frame being registered.

27. Congruencing is the process by which two images of a multi-image set are transformed so that the size and shape of any object on one image is the same as the size and shape of that object on the other image. In other words, when two images are congruenced, their geometries are the same and they coincide exactly.

28. Rectifying is a process by which the geometry of an image area is made planimetric. For example, if the image is taken of an equally spaced rectangular grid pattern, then the rectified image will be an image of an equally spaced rectangular grid pattern. Rectification

does not remove relief distortion.

29. Change detection is the process by which two images may be compared, resolution cell by resolution cell, and an output generated whenever corresponding resolution cells have different enough grey shades or grey shade n-tuples.

30. An optical color combiner is an instrument which produces "false" or "true" color images by linearly combining a few black and white transparencies of the same scene. The transparencies are usually obtained from multi-spectral, multi-band, or time-sequential photography. The transparencies are placed in projectors which are all focused and registered on the same screen and which have various color filters placed in front of their lenses. The viewing brightness of the projector's lamp in each projector can be changed independently thereby changing chromaticity balance. An optical color combiner is sometimes called an additive color display.

31. An electronic color combiner is an instrument which produces a "false" color image by linearly combining video signals of images of the same scenes. The images are usually obtained from multi-spectral, multi-band, or time-sequential photography. If the original image format is photographic, then the image format is changed from photographic to video signal format by synchronized vidicons or flying spot scanners. The resulting video signals are linearly combined through a matrix multiplier circuit, and the three linearly combined signals then drive the color gun of a color TV tube. An electronic color combiner usually has greater versatility for congruencing or registering than an optical color combiner.

32. Level slicing or density slicing or thresholding is an operation performed by an instrument (usually electronic) called a level slicer to change one or more a grey scale images to one binary image.

33. The level slicer, density slicer or thresholder is an instrument (usually electronic) which takes a single or multi-image as an input and produces a binary image for an output. A binary "one" is produced on the output image whenever the grey shades on each of the input images lie within the independently set minimum and maximum thresholds. A set of N input images would, therefore, require a setting N minimum and N maximum levels.

34. A figure F, or a subimage F in a continuous or digital image I is any function F whose domain is some subset A of the set of spatial coordinates or resolution cells, whose range is the set G of grey shades, and which is defined by F(x, y) = I(x, y) for any (x, y) belonging to A.

35. A figure F is connected if there is a path between any two spatial coordinates or resolution cells contained in the domain of F. More precisely, F is connected if for each pair of spatial coordinates (x, y) and (u, v) belonging to the domain of F, there exists some sequence  $\langle (a_1, b_1), (a_2, b_2), \ldots, (a_m, b_m) \rangle$  of spatial coordinates belonging to the domain

of F such that  $(x, y) = (a_1, b_1), (u, v) = (a_m, b_m)$ , and  $(a_i, b_i)$  and  $(a_{i+1}, b_{i+1})$  are sufficiently close neighboring coordinates, i = 1, 2, ..., m-1.

- 36. A figure F is convex if the domain of F contains the line segment which joins any pair of spatial coordinates in the domain of F.
- 37. A discrete tonal feature on a continuous or digital image is a connected set of spatial coordinates or resolution cells all of which have the same or almost the same grey shade.
- 38. Texture is concerned with the spatial distribution of the grey shades and discrete tonal features. When a small area of the image has little variation of discrete tonal features, the dominant property of that area is grey shade. When a small area has wide variation of discrete tonal features, the dominant property of that area is texture. There are three things crucial in this distinction: (1) the size of the small areas, (2) the relative sizes of the discrete tonal features, and (3) the number of distinguishable discrete tonal features.

39. Quantizing is the process by which each grey shade in an image of photographic, video, or digital format is assigned a new value from a given finite set of grey shade values. There are three often used methods of quantizing:

- (1) in equal interval quantizing or linear quantizing, the range of grey shades from maximum grey shade to minimum grey shade is divided into contiguous intervals each of equal length, and each grey shade is assigned to the quantized class which corresponds to the interval within which it lies:
- (2) in equal probability quantizing, the range of grey shades is divided into contiguous intervals such that after the grey shades are assigned to their quantized class there is an equal frequency of occurrence for each quantized grey shade in the quantized digital image or photograph; equal probability quantizing is sometimes called central stretching:
- (3) in minimum variance quantizing, the range of grey shades is divided into contiguous intervals such that the weighted sum of the variance of the quantized intervals is minimized. The weights are usually chosen to be the grey shade interval probabilities which are computed as the proportional area on the photograph or digital image which have grey shades in the given interval.
- 40. A quantizer is an instrument which does quantizing. The quantizer has three functional parts. The first part allows the determining and/or setting of the quantizing intervals, the second part is a level slicer which indicates when a signal is in any quantizing interval, and the third part takes the binary output from the level slicers and either codes it to some binary code or converts it to some analog signal representing quantizing interval centers or means.
- 41. The simplest and most practical unit to observe and measure in the pattern recognition of image data is often the basic picture element (the grey shade or the grey shade n-tuple in its particular resolution cell). This is what makes pattern recognition so hard sometimes for the objects requiring analysis or identification are not simple picture elements but are often complex spatial formations of picture elements such as houses, roads, forest, etc.
- 42. A measurement n-tuple or measurement pattern or pattern or measurement vector is the ordered n-tuple of measurements obtained of a unit under observation. Each component of the n-tuple is a measurement of a particular quality, property, feature, or characteristic of the unit. In image pattern recognition, the units are usually picture elements or simple formations of picture elements and the measurement n-tuples are the corresponding grey shades, grey shade n-tuples, or formations of grey shade n-tuples.

- 43. The range set  $R_i$  for the *i*th sensor which produces the *i*th image in the multiimage set, is the set of all measurements which can be produced by the *i*th sensor. Simply, it is the set of all grey shades which could possibly exist on the *i*th image.
- 44. The Cartesian product of two sets A and B, denoted by  $A \times B$ , is the set of all ordered pairs where the first component of the pair is some element from the first set and the second component of the pair is some element from the second set. The Cartesian product of N sets can be inductively defined in the usual fashion.
- 45. Measurement space is a set large enough to include in it the set of all possible measurement *n*-tuples which could be obtained by observing physical attributes of some set of units. When the units are single resolution cells or picture elements, measurement space M is the Cartesian product of the range sets of the sensors;  $M = R_1 \times R_2 \times \cdots \times R_n$ .

46. Each unit is assumed to be of one and only one given type. The set of types is called the set of pattern classes or categories C, each type being a particular category. The categories are chosen specifically by the investigator as being the ones of interest to him.

- 47. A feature or feature pattern or feature n-tuple or pattern feature is a n-tuple or vector with (a small number of) components which are functions of the initial measurement pattern variables or some subsequence of the measurement n-tuples. Feature n-tuples or vectors are designed to components in the given category set. Sometimes the features are predetermined and other times they are determined at the time the pattern discrimination problem is being solved. In image pattern recognition, features often contain information relative to grey shade, texture, shape or context.
  - 48. Feature space is the set of all possible feature n-tuples.
- 49. Feature selection is the process by which the features to be used in the pattern recognition problem are determined. Sometimes feature selection is called property selection.
- 50. Feature extraction is the process in which an initial measurement pattern or some subsequence of measurement patterns is transformed to a new pattern feature. Sometimes feature extraction is called *property extraction*.
  - 51. The word pattern can be used in three distinct senses:
  - (1) as measurement pattern;
  - (2) as feature pattern; and
  - (3) as the dependency pattern or patterns of relationships among the components of any measurement *n*-tuple or feature *n*-tuple derived from units of a particular category and which are unique to those *n*-tuples, that is, they are dependencies which do not occur in any other category.
- 52. A signature is the observable or characteristic measurement or feature pattern derived from units of a particular category. A category is said to have a signature only if the characteristic pattern is highly representative of the n-tuples obtained from units of that category. Sometimes a signature is called a prototype pattern.
- 53. A data sequence  $S_d = \langle d_1, d_2, \dots, d_J \rangle$  is a sequence of patterns derived from the measurement patterns or features of some sequence of observed units.  $d_1$  is the pattern associated with the first unit;  $d_2$  is the pattern associated with the second unit; and  $d_J$  is the pattern associated with the Jth unit.
- 54. A decision rule f usually assigns one and only one category to each observed unit on the basis of the sequence of measurement patterns in the data sequence  $S_d$  or in the corresponding sequence of feature patterns.

55. A simple decision rule is a decision rule which assigns a unit to a category solely on the basis of the measurements or features associated with the unit. Hence, the units are treated independently and the decision rule f may be thought of as a function which assigns one and only one category to each pattern in measurement space or to each feature in

56. A compound decision rule is a decision rule which assigns a unit to a category on the basis of some non-trivial subsequence of measurement patterns in the data sequence or in the corresponding sequence of feature patterns. A compound decision rule is not a simple

decision rule.

57. Provision can be made for the decision rule to reserve judgement or to defer assignment if the pattern is too close to the category boundary in measurement or feature space. With this provision, a deferred assignment is an assignment to the category of "reserved judgement."

58. A category identification sequence or ground truth  $S_c = \langle c_1, c_2, \dots, c_J \rangle$  is a sequence of category identifications obtained from some sequence of observed units.  $c_1$  is the category identification of the first unit;  $c_2$  is the category identification of the second unit;

and  $c_J$  is the category identification of the Jth unit.

59. A training sequence is a set of two sequences: (1) the data sequence and (2) a corresponding category identification sequence (sometimes called ground truth). The training sequence is used to estimate the category conditional probability distributions from which the decision rule is constructed.

60. The conditional probability of a measurement or feature n-tuple d given category c is denoted by  $P_c(d)$ , or by P(d/c), and is defined as the relative frequency or proportion of

times the n-tuple d is derived from a unit whose true category identification is c.

61. A distribution-free or non-parametric decision rule is one which makes no assumptions about the functional form of the conditional probability distribution of the patterns

given the categories.

62. A simple maximum likelihood decision rule is one which treats the units independently and assigns a unit u having pattern measurement or features d to that category cwhose units are most probable to have given rise to pattern or feature vector d, that is, such that the conditional probability of d given c,  $P_c(d)$ , is highest.

63. A simple Bayes decision rule is one which treats the units independently and assigns a unit u having pattern measurements or features d to the category c whose conditional

probability,  $P_d(c)$ , given measurement d, is highest.

64. Let  $\langle u_1, u_2, \dots, u_J \rangle$  be a sequence of units with corresponding data sequence  $\langle d_1, d_2, \ldots, d_J \rangle$  and known category identification sequence  $\langle c_1, c_2, \ldots, c_J \rangle$ . A simple nearest neighbor decision rule is one which treats the units independently and assigns a unit u of unknown identification and with pattern measurements or features d to category  $c_j$  where  $d_j$  is that pattern closest to d by some given metric or distance function.

65. A discriminant function  $f_i(d)$  is a scalar function, whose domain is usually measurement space and whose range is usually the real numbers. When  $f_i(d) \ge f_k(d)$ , k = 1, 2, ..., K,

then the decision rule assigns the ith category to the unit giving rise to pattern d. 66. A linear discriminant function f is a discriminant function of the form

$$f(d) = b + \sum_{j=1}^{n} a_j \delta_j$$
 where  $d = (\delta_1, \delta_2, \dots, \delta_n)$ .

67. A decision boundary between the *i*th and kth categories is a subset H of patterns in measurement space M defined by

$$H = \{d \in M | f_i(d) = f_k(d)\},$$

where  $f_i$  and  $f_k$  are the discriminant functions for the *i*th and *k*th categories.

68. A hyperplane decision boundary is the special name given to decision boundaries arising from the use of linear discriminant functions.

69. A linear decision rule is a simple decision rule which usually treats the units independently and makes the category assignments using linear discriminant functions. The decision boundaries obtained from linear decision rules are hyperplanes.

70. The pattern discrimination problem is concerned with how to construct the decision rule which assigns a unit to a particular category on the basis of the measurement pattern(s) in the data sequence or on the basis of the feature pattern(s) in the data sequence.

71. Pattern identification is the process in which a decision rule is applied. If  $S_u = \langle u_1, u_2, \dots, u_J \rangle$  is the sequence of units to be observed and identified, and if  $S_d = \langle d_1, d_2, \dots, d_J \rangle$  is the corresponding data sequence of patterns, then the pattern identification process produces a category identification sequence  $S_c = \langle c_1, c_2, \dots, c_J \rangle$  where  $c_i$  is the category in C to which the decision rule assigns unit  $u_i$  on the basis of the J patterns in  $S_d$ . In general, each category in  $S_c$  can be assigned by the decision rule as a function of all the patterns in  $S_d$ . Sometimes pattern identification is called "pattern classification" or "classification".

72. A cluster is a homogeneous group of units which are very "like" one another. "Likeness" between units is usually determined by the association, similarity, or distance between the measurement patterns associated with the units.

73. A cluster assignment function is a function which assigns each observed unit to a cluster on the basis of the measurement pattern(3) in the data sequence or on the basis of their corresponding features. Sometimes the units are treated independently; in this case the clustering assignment function can be considered as a transformation from measurement space to the set of clusters.

74. The pattern classification problem is concerned with constructing the cluster assignment function which groups similar units. Pattern classification is synonymous with numerical taxonomy or clustering.

75. The cluster identification process is the process in which the cluster assignment function is applied to the sequence of observed units thereby yielding a cluster identification sequence.

76. A misidentification, or misdetection, or type I error occurs for category  $c_i$  if a unit whose true category identification is  $c_i$  is assigned by the decision rule to category  $c_k$ ,  $k \neq i$ . A misidentification error is often called an error of omission.

77. A false identification, or false alarm, or type II error occurs for category  $c_i$  if a unit whose true category identification is  $c_k$ ,  $k \neq i$ , is assigned by the decision rule to category  $c_i$ . A false identification error is often called an error of commission.

78. A prediction sequence, or test sequence, or a generalization sequence is a set of two sequences: (1) a data sequence (whose corresponding true category identification sequence may be considered to be unknown to the decision rule) and (2) a corresponding category identification sequence determined by the decision rule assignment. By comparing the category identification sequence determined by the decision rule assignment with the

category identification sequence determined by the ground truth, the misidentification rate and the false identification rate for each category may be estimated.

79. A confusion matrix or contingency table is an array of probabilities whose rows and columns are both similarly designated by category label and which indicates the probability of correct identification for each category as well as the probability of type I and type II errors. The (ith, kth) element  $P_{ik}$  is the probability that a unit has true category identification  $c_i$ ; and is assigned by the decision rule to category  $c_k$ .

80. A unit is said to be detected if the decision rule is able to assign it as belonging only to some given subset A of categories from the set C of categories. To detect a unit does not imply that the decision rule is able to identify the unit as specifically belonging to one

particular category.

- 81. A unit is said to be recognized, identified, classified, categorized or sorted if the decision rule is able to assign it to some category from the set of given categories. In military applications, there is a definite distinction between recognize and identify. Here, for a unit to be recognized, the decision rule must be able to assign it to a type of category, the type having included within it many subcategories. For a unit to be identified, the decision rule must be able to assign it not only to a type of category but also to the subcategory of the category type. For example, a small area ground patch may be recognized as containing trees, which may be specifically identified as apple trees.
- 82. A unit is said to be *located* if specific coordinates can be given for the units physical location.
  - 83. A unit is said to be acquired if it can be located and recognized.
- 84, A target is one type of category used in the pattern recognition of image data. It usually occupies some relatively small area on the image and has a unique or characteristic set of attributes. It has a high a priori interest to the investigator.
- 85. Target discrimination is the process by which decision rules for targets (small area extensive categories) are constructed.
- 86. Target identification or target recognition is the process by which targets contained within image data are identified by means of a decision rule.
- 87. An image transformation is a function or operator which takes an image for its input and produces an image for its output. The domain of the transform operator is often called the spatial domain. The range of the transform operator is often called the transformed domain. Some transformations have spatial and transform domains of entirely different character. For these transforms, the image in the spatial domain may appear entirely different from and have a different interpretation from the image in the transformed domain. Specific examples of these kinds of transformations are the Fourier, Hadamard, and Karhunen-Loéve transformations. Other transformations have spatial and transform domain of similar character. For these transformations, the image in the transformed domain may appear similar to the image of the spatial domain. These types of transformations are often called spatial filters.
- 88. A spatial filter is an image transformation, usually a one-one operator used to lessen noise or enhance certain characteristics of the image. For any particular (x, y) coordinate on the transformed image, the spatial filter assigns a grey shade on the basis of the grey shades of a particular spatial pattern near the coordinates (x, y).
- 89. A linear spatial filter is a spatial filter for which the grey shade assignment at coordinates (x, y) in the transformed image is made by some weighted average (linear combination) of grey shades located in a particular spatial pattern around coordinates (x, y) of the domain image. The linear spatial filter is often used to change the spatial

frequency characteristics of the image. For example, a linear spatial filter which emphasizes high spatial frequencies will tend to sharpen the edges in an image. A linear spatial filter which emphasizes the low spatial frequencies will tend to blur the image and reduce salt and pepper noise.

90. Template matching is an operation which can be used to find out how well two photographs or images match one another. The degree of matching is often determined by cross-correlating the two images or by evaluating the sum of the squared corresponding grey shade differences. Template matching can also be used to best match a measurement pattern with a prototype pattern.

91. Matched filtering is a template matching operation done by using the magnitude of the cross-correlation function to measure the degree of matching.

92. In pattern recognition problems such as target discrimination, for which the category of interest is some specific formation of resolution cells with characteristic shape or tone-texture composition, the problem of pattern segmentation may occur. Pattern segmentation is the problem of determining which regions or areas in the image constitute the patterns of interest, i.e. which resolution cells should be included and which excluded from the pattern measurements.

93. Screening is the operation of separating the uninteresting photographs or images from those photographs containing areas of potential interest.

94. Preprocessing is an operation applied before pattern identification is performed. Preprocessing produces, for the categories of interest, pattern features which tend to be invariant under changes such as translation, rotation, scale, illumination levels, and noise. In essence, preprocessing converts the measurements patterns to a form which allows a simplification in the decision rule. Preprocessing can bring into registration, bring into congruence, remove noise, enhance images, segment target patterns, detect, center, and normalize targets of interest.

95. Image compression is an operation which preserves all or most of the information in the image and which reduces the amount of memory needed to store an image or the time needed to transmit an image.

96. Image restoration is a process by which a degraded image is restored to its original condition. Image restoration is possible only to the extent that the degradation transform is mathematically invertible.

97. Image enhancement is any one of a group of operations which improve the detectability of the targets or categories. These operations include, but are not limited to, contrast improvement, edge enhancement, spatial filtering, noise suppression, image smoothing, and image sharpening.

98. Image processing encompasses all the various operations which can be applied to photographic or image data. These include, but are not limited to, image compression, image restoration, image enhancement, preprocessing, quantization, spatial filtering, and other image pattern recognition techniques.

99. Interactive Image Processing refers to the use of an operator or analyst at a console with a means of assessing, preprocessing, feature extracting, classifying, identifying and displaying the original imagery or the processed imagery for his subjective evaluation and further interactions.

100. Pattern recognition is concerned with, but not limited to, problems of: (1) pattern discrimination, (2) pattern classification, (3) feature selection, (4) pattern identification, (5) cluster identification, (6) feature extraction, (7) preprocessing, (8) filtering, (9) enhancement, (10) pattern segmentation, or (11) screening.

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#### REFERENCES

- Afarani, M. K., Pattern Recognition Using Discrete Probability Distributions, Ph.D. Dissertation, University of Kansas, October, 1972.
- Anderson, J. R., E. E. Hardy, and J. T. Roach, "A Land-Use Classification System for Use with Remote-Sensor Data," Geological Survey Circular 671, U. S. Geological Survey, Washington, D. C., 1973.
- Cutrona, L. J., E. N. Leith, C. J. Palermo, and L. J. Porcello, "Optical Data Processing and Filtering Systems," <u>IRE Transactions on Information Theory</u>, vol.IT-6, no.3, pp. 318-400, June, 1960.
- Darling, E. M., and R. D. Joseph, "Pattern Recognition from Satellite Altitudes,"

  IEEE Transactions on Systems, Man, and Cybernetics, vol. SSC-4, pp. 38-47,

  March, 1968.
- Egbert, D., J. McCauley, and J. McNaughton, "Ground Pattern Analysis in the Great Plains," Semi-Annual ERTS A Investigation Report, Remote Sensing Laboratory, The University of Kansas Center for Research, Inc., Lawrence, Kansas, August, 1973.
- Fu, K. S., and J. M. Mendel, "Adaptive Learning and Pattern Recognition Systems," Academic Press, New York, 1972.
- Fukunaga, K., "Introduction to Statistical Pattern Recognition," Academic Press, New York, 1972.
- Goodman, J. W., "Introduction to Fourier Optics, McGraw-Hill Book Co., New York, 1968.
- Gramenopoulos, Nicholas, "Terrain Type Recognition Using ERTS-1 MSS Images,"

  Symposium on Significant Results Obtained From the Earth Resources

  Technology Satellite, NASA SP-327, pp. 1229-1241, March, 1973.
- Haralick, R. M., et al, "Preliminary Report on Land Use Classification Using Texture Information in ERTS-A MSS Imagery," Report No. 2262-1, NASA Goddard Space Flight Center Contract NAS 5-21822, The University of Kansas Center for Research, Inc., Lawrence, Kansas January, 1973.
- Haralick, R. M., et al, "Texture-Tone Study with Application to Digitized Imagery,"
  U. S. Army Engineer Topographic Laboratories Contract DAAK02-70-C-0388,
  CRES Technical Reports 182-2, and 182-3, The University of Kansas Center
  for Research, Inc., Lawrence, Kansas 1971, 1972.
- Haralick, R. M., "A Texture-Context Feature Extraction Algorithm for Remotely Sensed Imagery," Proceedings 1971 IEEE Decision and Control Conference, Gainesville, Florida, pp. 650-657, December, 15-17, 1971.
- Haralick, R. M., and D. E. Anderson, "Texture-Tone Study with Application to Digitized Imagery," CRES Technical Report 182-2, The University of Kansas Center for Research, Inc., Lawrence, Kansas, November, 1971.

- Haralick, R. M., K. Shanmugam, and I. Dinstein, "Texture Features for Image Classification," IEEE Transactions on Systems, Man, and Cybernetics, vol. SMC-3, pp. 610-621, November, 1973.
- Hardy, E. E., and J. R. Anderson, "A Land Use Classification System for Use with Remote-Sensor Data," <u>Machine Processing of Remotely Sensed Data</u>, (Conference Proceedings), Lafayette, Indiana, October, 1973.
- Horning, R. J., and J. A. Smith, "Application of Fourier Analysis to Multispectral/ Spatial Recognition," Management and Utilization of Remote Sensing Data ASP Symposium, Sioux Falls, South Dakota, October, 1973.
- Kaizer, H., "A Quantification of Textures on Aerial Photographs," Boston University Research Laboratories, Technical Note 121, 1965, AD 69484.
- Kirvida, L., and G. Johnson, "Automatic Interpretation of ERTS Data for Forest Management," Symposium on Significant Results Obtained from the Earth Resources Technology Satellite, NASA SP-327, pp. 1076-1082, March, 1973.
- Kullbach, S., Information Theory and Statistics, Wiley, 1957.
- Lendaris, G. G., and G. L. Stanley, "Diffraction-Pattern Sampling for Automatic Pattern Recognition," <u>Proceedings of the IEEE</u>, vol. 58, no. 2, pp. 198-216, February, 1970.
- Lewis, A. J., "Geomorphic Evaluation of Radar Imagery of Southeastern Panama and Northwestern Columbia," CRES Technical Report 133-18, The University of Kansas Center for Research, Inc., Lawrence, Kansas, February, 1971.
- MacDonald, H. C., "Geologic Evaluation of Radar Imagery from Darien Province, Panama," CRES Technical Report 133-6, The University of Kansas Center for Research, Inc., Lawrence, Kansas, July, 1969.
- Matherson, G., "Elements Pour Une Theorie des Milieux Poreaux, Masson, Paris, 1967.
- Miesel, W., "Computer Oriented Approaches to Pattern Recognition," Academic Press, New York, 1972.
- O'Neill, E., "Spatial Filtering in Optics," IRE Transactions on Information Theory, vol.1T-2,no.2, pp. 56-65, June, 1956.
- Preston, K., "Coherent Optical Computers, McGraw-Hill Book Co., New York, 1972.
- Read, J. S., and S. N. Jayaramamurthy, "Automatic Generation of Texture Feature Detectors," IEEE Transactions on Computers, vol. C-21, no. 7, pp. 803-812, July, 1972.
- Rosenfeld, A., and M. Thurston, "Edge and Curve Detection for Visual Scene Analysis," IEEE Transactions on Computers, vol. C-20, no. 5, pp. 562-569, May, 1971.

- Rosenfeld, A., and E. Troy, "Visual Textural Analysis," University of Maryland Computer Science Center, TR-70-116, June, 1970.
- Serra, J., and G. Verchery, "Mathematical Morphology Applied to Fibre Composite Materials," Film Science and Technology, vol. 6, pp. 141-158, 1973
- Shulman, A. R., Optical Data Processing, John Wiley & Sons, Inc., New York,
- Sutton, R., and E. Hall, "Texture Measures for Automatic Classification of Pulmonary Disease," IEEE Transactions on Computers, vol. C-21, no. 7, pp. 667-676, July, 1972.
- Swanlund, G., "Honeywell's Automatic Tree Species Classifier," Honeywell Systems and Research Division, Report 9D-G-24, December 31, 1969.
- Yaglom, A. M., Theory of Stationary Random Functions, Prentice-Hall, Inc., New Jersey, 1962.